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Maps and Plans in the Text

LESSON 7

Corrections for the Profit and Loss Account

IN Lesson 6 (Volume 3, page 30) we saw that certain adjustments had to be made in respect of stock-in-trade and the Trading Account In this Lesson we deal with certain other elementary adjustments that normally have to be made at the end of every trading period For the Profit and Loss Account to be an accurate record, corrections must be made for the following outstanding expenses; expenses paid in advance, bad debts, depreciation With regard to outstanding expenses at the end of the accounting year, certain expenses will usually have been incurred which will not be paid until the following period, and of which there is no record in the financial books For instance, it may happen, in the case of a concern whose accounting year ends on December 31, that the rent for the three months, October to December, may not be paid until the following January

If we assume that the Purchases Day-book does not include any expenses (some day-books contain analysis columns for certain of the more important expense items), then at December 31 there will be no entry in the books to record the fact that the rent is due The Rent account in the General Ledger will only have been debited with the payments in respect of the first nine months of the year If this total only were transferred to the debit of the Profit and Loss account, it is clear that the profit for the year would be overstated by the amount of three months' rent The Rent shown would not be the true rent for the year.

Let us assume that the rent of the premises occupied by the business is £100 per annum, payable in four quarterly instalments of £25, on March 31, June 30, September 30, and December 31, in respect of the preceding three months in each case The Rent account in the General Ledger would appear on December 31, as shown at A in the Table in page 11

It is assumed that the rent due on December 31, in respect of the last three months, had not been paid on that date.

Suspense Creditors Account. In order that the true rent for the year (£100) may be transferred to the Profit and Loss account, it is clear that another £25 must be debited to the Rent account. The corresponding credit cannot, however, be made to Cash, since no cash has been disbursed. This difficulty is overcome by opening a new account termed " Suspense Creditors," to which the £25 is credited.

The account will now appear as at B. In this way, it will be noted, the Profit and Loss account is debited with £100, the true expense for the year. The credit balance of £25 on the Suspense Creditors account is left as a balance in the books, and, therefore, must appear in the balance sheet, which is a list of all balances remaining after the nominal accounts have been closed off to the Profit and Loss Account. It will, of course, appear on the liabilities side. It will be noticed that this balance is not shown in the balance sheet simply because there is nothing else to do with it. On the contrary, it *must* appear, if the balance sheet is to be a complete statement of assets and liabilities, since a very clear and definite liability to pay this £25 to the landlord exists on December 31. This adjustment is a good illustration of the principle that double entry book-keeping is not merely a mechanical device, but is always a reflection of an actual state of affairs existing at a particular time.

With the commencement of the new accounting year, however, the balance on the Suspense Creditors account is " written back " to the Rent account on January 1. The final state of the accounts would then be as set out at C.

The Suspense Creditors account is now closed, and we are left, at the commencement of the new period, with a credit balance of £25 on the Rent account itself. This is necessary if the accounts of the new period are themselves to be correct.

Assuming the rent due on December 31 is paid during January, cash will be credited and the Rent account will be debited. If all the subsequent payments in this second year are all made on the due dates (including the last payment, on December 31), then it is clear that there will be five debts of £25 each, totalling £125. Now, just as it would have been incorrect to charge the Profit and Loss account with £75, so also it would be incorrect to transfer £125. The true rent is neither of these figures, but £100. In this case, however, the credit of £25 written back on January 1 reduces the *balance* of the Rent account to

PROFIT AND LOSS ACCOUNT

A

Rent Account.

Mar. 31 — To Cash ..	£25		
June 30 — " " ..	25		
Sept. 30 — " " ..	25		

B

Rent Account.

Mar. 31 — To Cash ..	£25	Dec. 31—By Profit & Loss account	£100
June 30 — " " ..	25		
Sept. 30 — " " ..	25		
Dec. 31 — To Suspense Creditors	25		
	£100		£100

Suspense Creditors.

		Dec. 31—By Rent account	£25

C

Rent Account.

Mar. 31 — To Cash ..	£25	Dec. 31—By Profit & Loss account	£100
June 30 — " " ..	25		
Sept. 30 — " " ..	25		
Dec. 31 — To Suspense Creditors	25		
	£100		£100
		Jan. 1 — By Suspense Creditors	25

Suspense Creditors.

Jan. 1 — To Rent ..	£25	Dec. 31 — By Rent ..	£25

D

Insurances.

1931.			
July 1 — To Cash ..	£20		

E

Insurances.

1931		1931	
July 1 — To Cash ..	£20	Dec. 31 — By Suspense Debtors	£10
		Dec. 31 — By Profit & Loss account	10
	£20		£20

Suspense Debtors.

1931			
Dec. 31 — To Insurances	£10		

o, which may be correctly transferred to the Profit and Loss ount. It may also happen that certain expenses are paid ore they are due, the payments having been debited to the propriate expense account. In such an event, the total debit the expense account in question will be greater than the true pense for the year. When the balance on the expense account ess than the true expense incurred, we have seen what adjustments are made. The adjustments in the converse case are nilar.

Suspense Debtors Account. Take the case of a man commencg business on January 1, 1931. For the first six months he ys no insurance, but on July 1 he takes out a policy and pays premium of £20, which covers him for the succeeding twelve onths. He makes up his accounts on December 31, on which ite there is a balance of £20 on the Insurance account, as shown . D in the Table in page 11.

Now this premium of £20 covers the period July 1, 1931, June 30, 1932. Therefore, only £10, or half, relates to the counting year 1931, and this amount only should be charged gainst the profits of that year. To enable this to be done the alance on the Insurance account at Dec. 31 must be reduced £10. This is done by crediting Insurances with £10, and debitng a new account, called "Suspense Debtors," with a similar um. The debit balance on Insurances account is now £10, nd this is transferred to the Profit and Loss account, as seen at E.

The Profit and Loss account has now been debited with the proportion of the premium that relates to the year under review. The debit balance on "Suspense Debtors" account appears as an asset in the balance sheet. This balance represents a very real benefit; the business possesses on December 31 the advantage of being insured for six months ahead. For if the premium lapsed on December 31, a further premium would have to be paid on January 1. The business is relieved of the necessity of making any fresh disbursement until the following July 1.

On the first day of the next accounting period (January 1, 1932) the Suspense Debtors account is "written back," i.e., Suspense Debtors is credited with £10, thus closing the account, and Insurances is debited with £10. This is correct, since this second half of the premium relates to the accounting year 1932, and must be included in the debits to the Profit and Loss account for that year.

LESSON 8

"Writing Off"

A DEBIT balance on a personal account is an asset. It represents the obligation of the debtor to pay at a future date the sum of money indicated. It is the right to receive cash, combined with the expectation of payment.

It may, however, happen that the debtor becomes insolvent, and is unable to pay. In such an event, the debt due ceases to be an asset. The mere right to receive cash, if it cannot be enforced, is worthless It is here that we may again observe the principle stated earlier, that is, that debit balances are either assets or losses. The debit balance on the personal account of an insolvent debtor ceases to be an asset and becomes a loss. An account headed "Bad Debts" is opened, and the balance on the personal account is transferred thereto. This is termed "writing off."

It is very likely that in the course of the year a number of bad debts will be sustained. All bad accounts are written off to the Bad Debts account, and the total of this account is ultimately transferred to the Profit and Loss account. For example:

John Smith.

To Goods	£300	By Bad Debts	£300

Bad Debts.

To J. Smith	£300	By P. and L.	£600
,, W. Robinson	250		
,, H. Jones	50		
	£600		£600

W. Robinson.

To Goods	£250	By Bad Debts	£250

H. Jones.

To Goods	£50	By Bad Debts	£50

The three amounts in this illustration, totalling £600, have been previously included in the credit to Sales account, and will, therefore, be included on the credit side of the Profit and Loss account; but since no cash will ever be received in payment for the goods, this credit must be offset by the debit of "Bad Debts."

Bad Debts Reserve. In many cases there may be some doubt as to the capacity of the debtor to pay. There is no *certainty* that he will be unable to pay, but there is a definite possibility. Now, if that is true of a number of personal accounts, it is morally certain that, in a proportion of the cases, the expectation of non-payment will be correct. Thus, at the time the Profit and Loss account is being prepared, there is a moral certainty of some loss, but no definite knowledge of its precise amount, or of which personal accounts will be involved.

It is, therefore, impossible to write off any specific accounts as definitely bad. On the other hand, since some loss is morally certain, some provision must be made; otherwise the net profit will be overstated. This provision is made by the creation of a Reserve for Bad and Doubtful Debts. An estimate of the total probable loss is made; this sum is debited to the Profit and Loss account, and is credited to a Reserve account. No entry is made in any of the personal accounts. The Reserve is shown in the balance sheet as a deduction from "Sundry Debtors," "Sundry Debtors" being the total of the sales ledger balances. Thus the *net* figure in the balance sheet is the same as it would have been had specific accounts, equal in total value to the amount of the reserve, been written off. The Reserve remains as a balance in the ledger until the following accounting period.

When this point has been reached, a number of the personal accounts which were previously doubtful will now be known to be definitely bad, and will be written off to the Bad Debts account. Other accounts, of course, may prove to be good. The total of the Bad Debts account may be transferred to the debit of the Reserve account.

But the story does not finish there. It now becomes necessary to make a fresh estimate of doubtful accounts at the end of this second period. The amount of this new reserve is debited to the Reserve account, and brought down to credit. The balance of the Reserve account is written off to the Profit and Loss account.

Consider the following example. A business commences on

January 1, 1931. At the end of the first year's trading it is estimated that the probable loss from doubtful debts will be £500, and a reserve of this amount is created. During 1932 personal accounts totalling £400 are written off as bad. On December 31, 1932, the total of all sales ledger balances, *excluding* those that have been written off as bad, is £10,000. It is estimated that 10 per cent of these debts will prove to be bad, and it is determined to bring the Reserve up to this figure.

The Reserve for Bad and Doubtful Debts will appear as follows:

Reserve for Bad and Doubtful Debts.

1931.			1931		
Dec. 31.	To Balance *c/d*	£500	Dec. 31.	By Profit & Loss *a/c*..	£500
		£500			£500
1932.			1932.		
Dec. 31.	To Bad Debts *a/c* ..	£400	Jan. 1.	By Balance *b/d*	£500
„ 31.	To Balance (closing reserve)	1,000	Dec. 31.	By Profit & Loss *a/c* ..	900
		£1,400			£1,400
			1933.		
			Jan. 1.	By Balance ..	£1,000

It will be noted that: 1. The debit to Profit and Loss for 1931 is £500. 2 The reserve deducted from Sundry Debtors in the Balance Sheet of December 31, 1931, is £500. 3. That Bad Debts actually written off in 1932 are only £400, which is £100 less than the estimate 4. The debit to Profit and Loss for 1932 is £900. This amount is made up in this way. It is estimated that £1,000 of the debtors' accounts at December 31, 1932, will be bad; bu the debit to Profit and Loss at December 31, 1931, turns out to have been excessive to the extent of £100. By charging to P. & L. at December 31, 1932, £100 *less* than the amount of the estimated loss, the total debit to P. & L. for the two years taken together is correct, always assuming, of course, that the final estimate is correct:

Debit to P. and L., 1931	£500
„ „ „ 1932	900
	£1,400

›ts known to be Bad and written off	... ...	£400
ances estimated Bad, Dec. 31, 1932	... ...	1,000
		£1,400

5. The Reserve deducted from Sundry Debtors (not including › £400 written off) is £1,000, which is the proportion of the bts then due, which it is not expected to realize

Allowance for Depreciation. Assets may be divided into ›ating and fixed assets. Floating assets consist either of sh, or of assets which will eventually be converted into cash, ch as Debtors or Stock-in-trade; with these we are not at the oment concerned Fixed assets are those which are acquired ith a view to permanent retention, and not with a view to ›-sale and conversion into cash. They are held in order to ›able the business to earn profits. Some fixed assets are nown as wasting assets; that is to say, they gradually wear ut and shrink in value as they are used. Examples of wasting ssets are office furniture, plant and machinery, leaseholds, and lotor vans. It is in connexion with wasting assets that we will onsider depreciation.

It is clear that, as a wasting asset gradually wears out, it annot be allowed to remain in the books at its original cost price. 'his original value must be gradually reduced as the real value hrinks. The double entry by which this reduction in value s recorded is a credit to the asset account, thus reducing the ›alance remaining, and a debit to the Profit and Loss account.

The question at once arises: By what amount are we to educe a given wasting asset in a given year? It must at once ›e understood that the market price or the selling value of the ısset has no bearing whatever on this question. Fixed assets are not held with a view to re-sale, and, therefore, the market price is entirely irrelevant.

The true nature of wasting assets is that they represent revenue expenditure (i.e. business expense) paid in advance. The only difference between the cost of a machine which lasts for five years and the cost of a man's labour for a week is one of time. Both are expenditures necessarily incurred in earning profits; both must, therefore, be charged against profits. This is at once apparent if we consider the position at the end of five years. By that time our machine is worn out, and useless; the money

we paid for it is now represented by nothing of any value. Clearly, over a period of five years, the cost of that machine is just as much an expense as wages, rent or lighting.

The problem of depreciation only arises because accounts are usually prepared once every year, and not once in five years, and the object of depreciation will be to spread the cost of the machine over the Profit and Loss accounts of the five years during which it is used. This may be done by writing off one-fifth of the original value of the machine to Profit and Loss at the end of each year, as shown in the following Table:

Machine Account (Life, 5 years).

1925.			1925.		
Jan. 1.	To Cash	£500	Dec. 31.	By Depreciation	£100
			"	By Balance ..	400
		£500			£500
1926.			1926.		
Jan. 1.	To Balance ..	£400	Dec. 31.	By Depreciation	£100
			"	By Balance ..	300
		£400			£400
1927.			1927.		
Jan. 1.	To Balance ..	£300	Dec. 31.	By Depreciation	£100
			"	By Balance ..	200
		£300			£300
1928.			1928.		
Jan. 1.	To Balance ..	£200	Dec. 31.	By Depreciation	£100
			"	By Balance ..	100
		£200			£200
1929.			1929.		
Jan. 1.	To Balance ..	£100	Dec. 31.	By Depreciation	£100
		£100			£100

The Depreciation account is, of course, transferred to the Profit and Loss account. The balance on the Machine account at the end of, say, 1926, simply represents that proportion of the original cost which is determined by the ratio of the unexpired life of the machine to the total life of the machine.

LESSON 9

The Balance Sheet of a Small Business

THE general principles of book-keeping, classification of accounts, divisions of the ledger, bad debts, and depreciation entries, etc., which have been explained in the first eight Lessons in this Course in Accountancy may, perhaps, be more readily understood by studying a practical illustration, which includes examples of all the adjustments to which references have been made The following is the trial balance of a sole trader on a small scale, as taken out at December 31, 1932 :

TRIAL BALANCE.

	Dr.	Cr.
Capital account—J. Harris		2,000
Loan account—A Harris		500
Motor vans	840	
Fixtures and fittings	500	
Stock in trade, Jan. 1, 1932	2,850	
Sundry debtors	4,525	
Sundry creditors		5,785
Purchases	28,320	
Sales		33,830
Returns inwards	500	
Returns outwards		400
Wages	1,840	
Rent	240	
Telephone	12	
Insurances	20	
Gas	12	
Electricity	8	
Sundry expenses	88	
Rates	75	
Bank charges	10	
Audit fee	42	
Carriage	170	
Discounts	955	730
Interest on deposit		5
Drawings	900	
Income tax	63	
Bad debts reserve		180
Cash at bank	460	
Deposit account	1,000	
	£43,430	£43,430

BALANCE SHEET

This gives us a picture of all balances in the ledger of J. Harris at December 31, 1932. The following adjustments are to be made:

3 months' rent is outstanding	..	..	£80
„ „ gas „ „	..	..	4
„ „ electricity „	..	..	3
„ „ telephone „	..	..	3
Insurance paid in advance	..	..	4

The stock on December 31 is valued at £3,220. The motor vans are to be depreciated at 20 per cent p a of the original cost, which was £1,000. The fixtures and fittings are to be depreciated at 5 per cent on the balance outstanding.

£325 of the book-debts are to be written off as bad; in addition, the reserve for bad and doubtful debts is to be increased to 5 per cent of the total debts outstanding.

The trading and profit and loss account is prepared by transferring thereto the balances of the nominal accounts. It should be remembered that the trading and profit and loss account is a ledger account, and that all entries therein require an equal and opposite debit or credit in some other account.

The appropriate entries to give effect to the above adjustments must also be made. The trading and profit and loss account will be as shown in the next page.

Having prepared the trading and profit and loss account, the balance sheet can be drawn up, as shown in page 21. This consists of a list of all balances remaining after the closing of the nominal accounts.

It should be noted that the balance sheet is *not* a ledger account. It is merely a list of balances. The preparation of the balance sheet does not require any entries in the ledger.

The Adjusting Entries. (1) Stock at December 31. The trading account is credited with £3,220, and a new stock account is debited. This item remains as a balance in the ledger, and appears, therefore, in the balance sheet.

It must be appreciated that the purpose of the trading account is to compare the total value of all sales with the cost of the goods sold. The stock of goods at the beginning of the accounting period (at cost price), with purchases (also at cost price), together equal the cost of all goods available for sale; but not all these goods are sold. In order, therefore, to arrive at the cost of the

goods which have been sold, the cost price of the closing stock must be deducted. This is done by crediting closing stock to the trading account. A better method of presentation would be to show the value of closing stock as a deduction from the debits to the trading account, since in this way the cost of goods sold would be thrown up as a single figure.

TRADING AND PROFIT AND LOSS ACCOUNT.

To—			By—		
Stock		£2,850	Sales	£33,830	
Purchases.. ..	£28,320		*Less* returns ..	500	
Less returns ..	400				33,330
		27,920	Stock		3,220
Gross Profit carried down		5,780			
		£36,550			£36,550
To—			By—		
Wages		£1,840	Gross profit, brought down		£5,780
Rent		320	Discounts		730
Rates		75	Interest on deposit ..		5
Lighting and heating ..		27			
Telephone		15			
Insurances		16			
Carriage		170			
Discounts		955			
Sundry expenses		88			
Bank charges		10			
Audit fee		42			
Bad debts		355			
Depreciation—					
Motor van	£200				
Fixtures and Fittings ..	25				
		225			
		4,138			
Net profit transferred to Capital account.. ..		2,377			
		£6,515			£6,515

(2) Expenses accrued due. The appropriate expense accounts ·e debited with the amounts outstanding and a collective suspense creditors " account is credited. The expense accounts e then closed off to the profit and loss account, while the balance ı " suspense creditors " appears in the balance sheet.

(3) Insurance paid in advance. The insurance account is credited with the amount to be carried forward, thus reducing the balance to be transferred to the profit and loss account, and a "suspense debtors" account is debited. The balance of this account (debit) appears in the balance sheet as "insurance paid in advance."

(4) Depreciation. The asset accounts (motor vans and fixtures and fittings) are credited with the amounts to be written off, and a depreciation account is debited. The depreciation account is closed by transfer to the profit and loss account, while the

BALANCE SHEET.

As at December 31, 1932.

Capital Account				Cash at Bank		
As at Jan. 1 ..		£2,000		Current account	£460	
Add Net profit ..		2,377		Deposit account	1,000	
						£1,460
		£ 4,377		Sundry Debtors	4,200	
Less Drawings	900			*Less* reserve ..	210	
Income tax ..	63					3,990
		963		Stock in trade ..		3,220
			£3,414	Insurance paid in advance		4
Loan account ..			500	Motor vans		
Sundry creditors				As at Jan. 1 ..	840	
Trade		5,785		*Less* depreciation	200	
						640
Expenses accrued		90		Fixtures & fittings		
			5,875	As at Jan. 1 ..	500	
				Less depreciation	25	
						475
			£9,789			£9,789

balances of the asset accounts (reduced by the amount of the depreciation) appear in the balance sheet.

(5) Bad Debts and Bad Debts Reserve. If it is definitely known that certain debtors are unable to pay, the personal accounts in the sales ledger are credited, and "bad debts" account is debited.

If, in addition, a proportion of the remaining book-debts are expected to be bad, profit and loss account will be debited with the amount of the anticipated loss, and a "reserve" account will be credited.

In the above example, the balance on the reserve account at January 1 was £180. On December 31 it was found necessary

to increase the reserve by £30 to £210. The personal accounts actually written off totalled £325, thus making a total of £355 to debit to profit and loss. The bad debts reserve account would appear as follows:

To—		By—	
Bad debts	£325	Balance	£180
Balance	210	P. & L.	355
	£535		£535
		By balance	£210

The total anticipated loss due to the inability of debtors to pay amounts to £535. But £180 of this has already been provided for by debiting the profit and loss account of the previous year, thus leaving only £355 to be charged in 1932.

Making allowances for the foregoing adjustments, it would be advisable for the student to check the profit and loss account and balance sheet by reference to the trial balance. A detailed scrutiny, item by item, of these specimen accounts will be found to aid comprehension.

Special Points. (1) Discounts. Personal accounts of debtors are credited, and "discounts" account debited; personal accounts of creditors are debited, and "discounts" credited. The amount of cash necessary to settle the personal account is thus diminished.

(2) Returns. The entries are simply reversals of the entries necessary to record purchases and sales on credit. For returns outwards, debit the personal account and credit "returns outwards." For returns inwards, credit the personal account of the customer, and debit "returns inwards."

(3) The Capital Account. The balance of the profit and loss account is credited to the proprietor's capital account. A profit is necessarily represented by an increase in net assets, which belong to the proprietor. His capital account shows the value of his possessions—the excess of his assets over his liabilities, which is increased by a profit. This excess, however, is diminished if the proprietor withdraws cash from the business for his own private use. The amount of the proprietor's "drawings," as such withdrawals of cash are termed, is, therefore, debited to his capital account. Such an entry is clearly necessary if the capital account is to record the amount by which assets exceed

liabilities. Assets (i.e. in this case, cash) are diminished by drawings; the capital account must be diminished to an equal extent.

(4) Income Tax. It will have been noticed that income tax has been debited to the capital account, and not to the profit and loss account. That is to say, income tax has been added to drawings, or the proprietor's private expenditure, and not to business expenses. A little reflection will show that this is the correct view. A person earning a salary does not regard his income tax payments as being a reduction of salary; he regards it as a payment *out of* his salary, or income. In the same way, the profit and loss account of a business is designed to show the income of the proprietor. Income tax is paid out of that income; it is not a payment which reduces the amount of income.

LESSON 10

Special Features of Partnership Accounts

This Lesson, and those immediately following, will deal with accounting features due to peculiarities of ownership and organization. We have up to the present assumed the ownership of a business to vest in a single individual. In the majority of undertakings, however, ownership is shared by a number of individuals. Such undertakings are of two types—partnerships and limited companies. The accounts of the former will be considered first.

Partnership is defined by the Partnership Act of 1890 as "the relation which subsists between persons carrying on business in common with a view of profit." It is sometimes difficult to determine exactly what constitutes a partnership, since certain types of business arrangements partake of some of the attributes of partnership, but not of all of them. For instance, an employee or servant may be remunerated by a share of the profits of a business, but that does not necessarily make him a partner. In general terms, however, the right to a share of the profits of a business is *prima facie* evidence that the recipient is a partner, and if anyone claims the contrary, positive evidence to the contrary must be produced.

Each partner is liable for the debts and obligations of the firm to the full extent of all his personal property, and not merely to the extent of his share of the partnership property Should the assets of a partnership be insufficient to pay the firm's debts, the partners must make good the deficiency out of their private resources. All partners must contribute to such a deficiency ; but if, for instance, one of two partners is insolvent, the other is then bound to make good the whole of the deficiency, even if it entails the sacrifice of all his personal effects.

For this reason, partnerships are less popular than limited companies. The liability of the members of companies is limited to the nominal value of the shares which they subscribe. On the other hand, however, companies must comply with a number of legal regulations, which to some extent restrict complete freedom of action. Partnership, therefore, continues to emain as a form of business organization which is becoming nore and more confined to the smaller type of business

Provisions of the Partnership Act. Normally, partners will raw up a document termed a partnership agreement, which will efine their rights and duties as between themselves ; but such a ritten agreement is not essential—agreement may be verbal understood. If, however, there is no agreement, either written understood, then certain rules laid down by the Partnership ct apply. The provisions which affect the accountant are as llow :

(1) All partners are entitled to share equally in capital and ofits and losses.

(2) Partners are not entitled to interest on capital.

(3) Partners are not entitled to salaries for their services.

(4) Partners are, however, entitled to interest at 5 per cent annum on loans.

t must not be assumed, if one partner contributes a larger re of the original capital of the firm than the other partners t the total capital must be credited in equal proportions to 1 partner. Even if there were no written agreement, the e fact of unequal contributions would imply an understanding hare capital in those proportions. In the absence of specific ement, however, profits must be shared equally, even if tals are unequal. Similarly, losses would be borne equally. ractice, however, there will usually be a specific agreement ll these points.

It is important to notice that the proportions in which partners contribute the capital of the firm are not necessarily, or even usually, the proportions in which they share profits. If partners, *for instance, agree to share profits equally, while they have con*tributed capital in unequal proportions, it is possible to compensate those partners who have contributed larger shares of capital by an agreement to credit all partners with interest on capital. Such interest would be debited to the Profit and Loss Account of the firm, and credited in the due proportions to the capital *accounts of the partners. It will be realized that the* effect of this entry is to diminish the balance of profit available for division. Now, the interest on partners' capitals is not a business expense in the ordinary sense. Practically speaking, the entry debiting profit and loss and crediting partners' capitals amounts to a transfer of a portion of the net profit

Division of Profits. *The final effect of the transaction is that* the true net profit of the concern is divided unequally. The circumstances of the case make it impossible to arrange an equitable division of profits by an agreement to share in fixed proportions, and so a somewhat more complex method is adopted. Under such a method the partner who has made the largest contribution to capital receives, in effect, the largest share of the profits ; but the amount by which his share of the profits exceeds the shares of the other partners is limited to a fixed sum, which is a different thing from a fixed proportion. And if all the partners, by their work, contribute equally to the prosperity of the business, it is reasonable that the extra compensation for a larger contribution of capital should be limited to interest on the excess.

On the other hand, it frequently happens that one or more partners devote more time to the business than others. The usual practice in such a case is for the partners who devote most time to the business to receive an agreed salary, irrespective of what their shares of the net profit may be

The effect of all these circumstances on the books of account can now be briefly considered. In the first place, there will be not one capital account, as in the books of a sole trader, but one capital account for each partner. To these accounts will be credited, first, the amount of each partner's original contribution ; secondly, if so agreed, interest thereon annually ; thirdly, in some cases, a salary ; and, fourthly, a share of the final net profit. Should a loss be incurred, a share of the loss will be

ɔd to each capital account. Any sums withdrawn by a er, whether in respect of interest, salary, or profit, are ɔd to his capital account. The balances on all the capital ınts combined represent the net worth of the business, that ıe excess of assets over liabilities. The balance on each er's account shows the share of each in the ownership of the ssets, and is the amount which each would receive in cash business were wound up and all assets sold at a price equal ıeir book value.

qualification must here be introduced. The usual practice esent is to divide each partner's capital account into two ɔns, one of which includes only the partner's original contion, while the second section is reserved for interest, salary, ːs and losses, and drawings. This second section is termed ɔurrent account.

e following example shows typical accounts. A, B, and C artners, sharing profits and losses in the proportions 3 : 2 : 1. ɔr the partnership agreement, interest on capital is charged ɔer cent p.a. C receives a salary of £200 p.a. On Dec. 31, the following balances appear in the partnership books:

A.	Capital account	..	£10,000
B.	" "	..	8,000
C.	" "	..	2,000
A.	Current account	..	1,000
B.	" "	..	500
C.	" "	..	100
B.	Loan account	..	1,000

e net profit for the year, before charging interest on capital, ·st on B's loan, or C's salary, amounts to £3,050.

ıwings for the year amount to:

A.	..	..	£1,500
B.	..	..	900
C.	..	..	750

ɜ Profit and Loss Account is usually balanced before charging ıternal items of the above nature, and the balance is brought to an account termed the Profit and Loss Appropriation ınt. In this account, which appears in the ledger as a ıuation of the Profit and Loss Account proper, the division ɔfits between the partners is dealt with, for it must be re-

membered that interest on capital, etc., are not expenses in the true sense.

PROFIT AND LOSS APPROPRIATION ACCOUNT.

To—			By—	
Interest on Capital :		£	Balance b/d	£3,050
A.	500			
B.	400			
C.	100			
		1,000		
Interest on Loan, B. ..		50		
Salary, C.		200		
Net Profit transferred to Current accounts :				
A.	900			
B.	600			
C.	300			
		1,800		
		£3,050		£3,050

CURRENT ACCOUNT. A.

To—		By—	
Drawings	£1,500	Balance	£1,000
Balance c/d	900	Interest	500
		Net Profit ..	900
	£2,400		£2,400
		By—	
		Balance b/d	£900

CURRENT ACCOUNT. B.

To—		By—	
Drawings	£900	Balance	£500
Balance c/d	650	Interest	400
		,, ...	50
		Net profit	600
	£1,550		£1,550
		By—	
		Balance b/d	£650

CURRENT ACCOUNT. C.

		By—	
ings	£750	Balance	£100
		Interest	100
		Salary	200
		Net profit	300
		Balance c/d	50
	£750		£750

ıce c/d £50

that a partner's loan account must not be confused with tal account. A loan is not a contribution to capital In nt of the business being wound up and the proceeds of ·ts being insufficient to meet the partners' capitals in full, ıy partners' loans would take priority of capital, and ɔe paid before making any division on account of capital

LESSON 11

urther Analysis of Partnership Accounts

E ordinary trading records of a partnership concern are in no way different from those of a sole trader It is, however, as we have seen, necessary to keep accounts ɔh the rights of the partners, as between themselves, tal and to profits are recorded The adjustment of these requires special treatment upon a change in the con- n of the firm, that is, upon the admission of a new partner, ı the death or retirement of an existing partner, and also, ɔe clear, in the event of a dissolution of the partnership.
erms upon which a new partner will be admitted into an ; business will be a matter for individual agreement in ase, but he will normally be required to introduce a certain of fresh capital. Whatever sum he contributes will be l to his capital account.

MORE ON PARTNERSHIP ACCOUNTS

A partner, by definition, is entitled to a share of the profits of the business in which he participates; it therefore follows that the existing owners, if they decide to admit a new partner, will be surrendering their right to a part of the future profits of the undertaking. In return for this surrender, they will usually require some compensation. This compensation may take the form of a money payment, termed a premium. The new partner is, in effect, purchasing a part of the goodwill, since goodwill may be defined as the right to future profits. The premium usually paid for a share of the goodwill must not be confused with the capital usually brought in by a new partner. Any sum introduced as capital does not directly benefit the existing partners This amount is credited to the capital account of the new partner, and represents his share in the ownership of the assets of the business; and, if the undertaking were subsequently dissolved, it would be returned to him.

The premium for goodwill, however, need not appear in the books of the firm at all; it may be paid direct to the existing partners, who may treat it as a completely private possession. Should the premium be paid into the firm, it will be credited to the capital accounts of the existing partners in the proportions in which they share profits; for, since goodwill is simply the capitalized value of the right to future profits, the proportion in which partners are entitled to receive future profits is the same as that in which they share the ownership of the goodwill.

Consider the following example: A and B are in partnership, sharing profits in the proportions of 3 to 2. On January 1st, 1932, they decide to admit C as a partner; C is to bring in £5,000 as capital, and is to pay a premium of £1,000 for a one-fifth share of the goodwill. The balance sheet of A and B, prior to the admission of C, is as follows:

A and B.

Capitals: A	£6,000	Sundry Assets ..	£12,000
B	4,000		
Creditors	2,000		
	£12,000		£12,000

The balance sheet, after the admission of C, will be:

A, B and C.

:als : A	£6,600	Sundry Assets	£12,000
B	4,400	Cash from C	6,000
C	5,000		
itors	2,000		
	£18,000		£18,000

ıd A and B received the £1,000 privately from C, and sub-
ently decided to invest it in the firm as additional capital,
position would still be as above set forth.

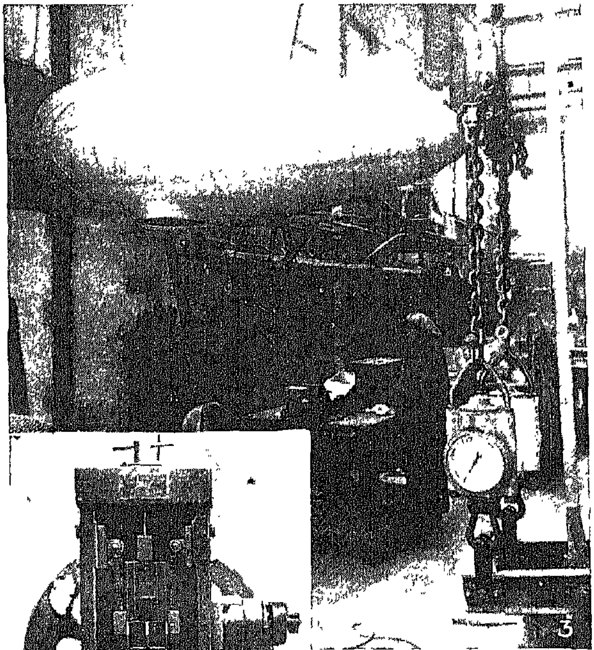
some cases, however, a new partner is not required to pay
emium. In such an event, the existing partners will usually
pensate themselves by raising a goodwill account in the books
ıe firm. If we take the same set of circumstances as in the
e illustration, and assume that C can only raise £5,000,
, since the premium for which C had been asked was £1,000 for
e-fifth share of the goodwill, it follows that the whole good-
is worth £5,000. A double entry would be passed,
ting a new account, headed "goodwill," with £5,000,
crediting £3,000 to A's capital account and £2,000 to B's
tal account.

ıe balance sheet is then as follows :

A, B and C.

itals : A	£9,000	Sundry Assets	£12,000
B	6,000	Cash from C	5,000
C	5,000	Goodwill	5,000
litors	2,000		
	£22,000		£22,000

will be noted that no goodwill is credited to C's capital
unt. Now, normally, the goodwill account will not be allowed
emain in the books. It will be written off ; that is to say,
ouble entry will be passed crediting goodwill account with
oo and debiting the capital accounts of the *three* partners,
he proportions in which they share profits and losses, i.e.
$\frac{2}{5}$, B $\frac{8}{25}$, and C $\frac{5}{25}$. For since C is now a partner he must



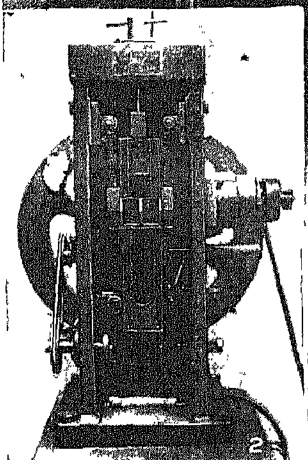
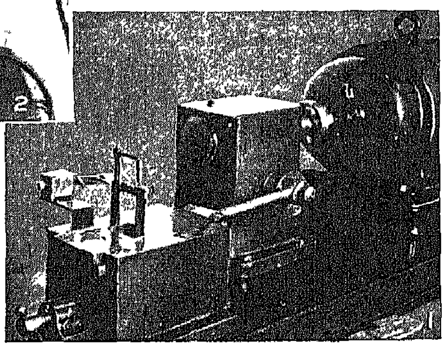
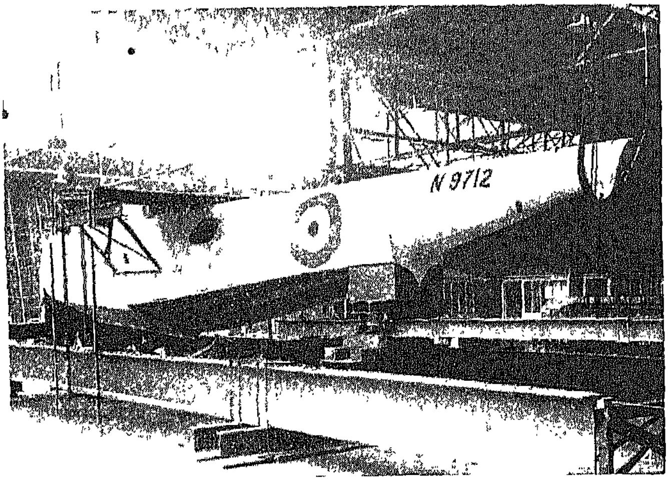
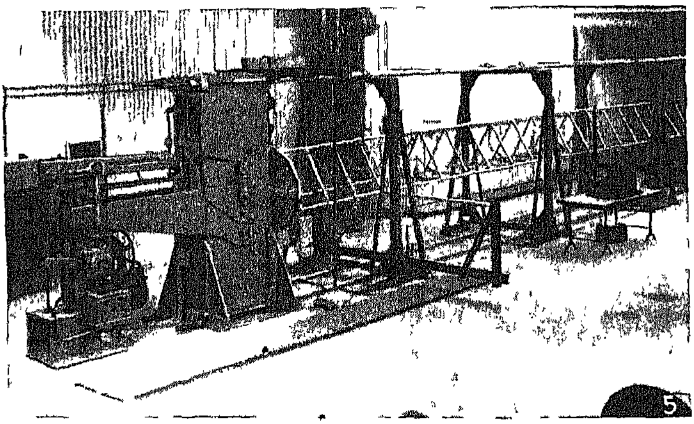


Fig 3 Test being carried out on an all metal engine nacelle for a three engined flying boat
AERONAUTICS 20
Courtesy of The Royal Aeronautical Society



TESTING OF AIRCRAFT MATERIALS
Fig. 1. Machine for testing and recording the fatigue of metals
Fig. 2. Amsler impact testing machine
AERONAUTICS 20
Courtesy of The Royal Aeronautical Society





TESTING OF AIRCRAFT MATERIALS. Fig. 4 Flying boat under test for landing in rough water, the assumption is made that the boat lands on two waves receiving severe shocks at each end from the impact, and loads are applied by means of screw jacks and levers **Fig. 5** Metal built up spar under test for increasing loads the load is increased until the spar breaks AERONAUTICS 20

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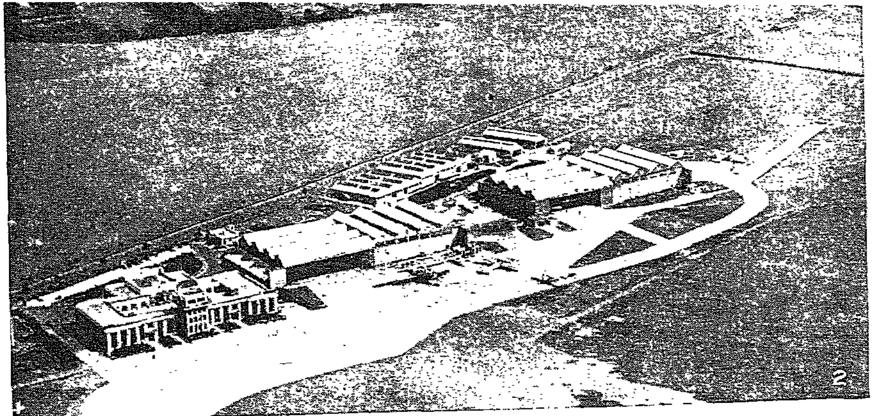
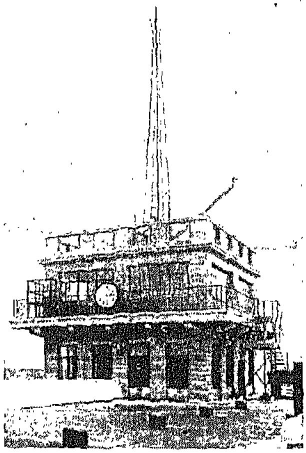
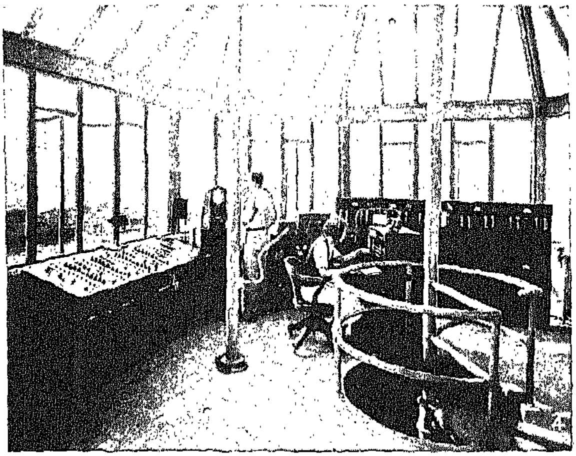


CROYDON AIRPORT. Fig. 2. Air view of Croydon aerodrome. The control tower, of which an enlarged view is given in Plate 4, is seen among the buildings on the left, where also are a hotel, customs room, passengers' waiting rooms, etc. To the right are the hangars and sweeping round are the concrete runways or aprons. AERONAUTICS 21

Photo. A. W. Hobart





AERODROME CONTROL TOWERS. Fig. 3. Control tower at Croydon aerodrome; in addition to the main control room, it includes a meteorological office and a wireless room where the latest weather reports are received and broadcast to pilots, who are able to keep in touch with the aerodrome throughout their journey. **Fig. 4.** Interior of the control tower at Wayne airport, Indiana, U.S.A. AERONAUTICS 21
Courtesy of The Royal Aeronautical Society

LESSON 12

Dissolution of Partnership

When a partnership is dissolved, it becomes necessary to distribute the assets among the partners, and to determine the amount due to each. The first step will be to prepare a Profit and Loss account up to the date of dissolution, and to credit each partner with his share of the profit accrued.

It will be remembered that it does not follow that the value of the assets as shown in the Balance Sheet is always their true value. For purposes of dissolution the true value must be *ascertained. The normal practice is to realize, or sell, the assets,* and to distribute the proceeds. The business may be sold as a going concern, for a lump sum, or, alternatively, the assets may be realized piecemeal. In some cases a proportion or all of the assets may be taken over by one or more of the partners at an agreed valuation. From the point of view of the partnership, *it makes no difference whether assets are purchased by partners* or by outside individuals; a partner purchasing partnership assets does so in his private capacity, and is liable to account to the firm for the purchase price, in the same way as any other purchaser. The circumstances under which the assets are realized may vary in many ways, but in every case the principle is the same: the assets of the partnership are sold, and the proceeds are used, first, to pay the liabilities of the firm, and, secondly, to repay the partners' capitals.

From what has been said, it will be clear that the proceeds of the realization may be greater or less than the book value of the assets. Any surplus or deficiency is a profit or a loss, and must be shared by the partners in the same proportions as any normal profit or loss upon trading.

The accounting procedure for these transactions is as follows:

(1) The assets must be transferred to a Realization account, which is opened for the purpose.

(2) As the assets are sold, the proceeds are credited to the Realization account.

The Realization account now becomes a kind of Profit and Loss account. On the debit side appears the book value of the

assets to be sold; on the credit side appears the selling price. The difference between the two sides of the account is the Profit or Loss on Realization, and is transferred to the Capital accounts of the partners, in the proportions in which they share profits.

(3) The proceeds of the Realization account are debited to Cash account. The liabilities are paid off, and the balance of the Cash account should now equal the total amount standing to the credit of the partners' Capital accounts. An entry crediting Cash and debiting the partners' Capital accounts will now close the books of the firm.

The following example illustrates this procedure.

A, B and C are in partnership, sharing profits in the proportions 5, 3, 2. On June 30, 1932, they decide to dissolve partnership, and on that date the Balance Sheet of the firm is as follows:

A, B and C.

Capital Accounts:			Cash at Bank	£700
A ..	£8,000		Sundry Debtors ..	6,000
B ..	3,500		Stock in Trade.. ..	8,600
C ..	500		Leasehold Premises..	2,400
		12,000	Plant and Machinery	5,300
Loan Account, B ...		1,000		
Sundry Creditors ...		10,000		
		£23,000		£23,000

The assets are at once realized, at the following figures: debtors, £5,400; stock, £5,000; leasehold premises, £3,200; while the plant and machinery are taken over by A, at an agreed valuation of £2,700. All the asset accounts, with the exception of cash, will be closed by transfer to the debit of Realization account, which will appear as shown in the next page.

The Realization account has been credited with the cash proceeds, the corresponding debit being, of course, to the Cash account. Strictly speaking, A should pay £2,700 in cash for the plant and machinery, but, since the final balance on A's Capital account will exceed this figure, and, since, therefore, A will receive a larger sum in cash when the final distribution is made, it is more convenient to debit this amount of £2,700 to his Capital account, thus reducing the amount he will receive

Whichever method is employed, the result is the same The method here adopted reduces the transferring of cash to a minimum

Realization Account

To—		By Cash—		
Sundry Debtors ..	£6,000	Debtors	£5,400	
Stock in Trade ..	8,600	Stock ..	5,000	
Leasehold Premises	2,400	Premises	3,200	
Plant and Machinery.. ..	5,300			13,600
		A—Plant and Machinery		2,700
				16,300
		Loss on Realization—		
		A, $\frac{5}{10}$ ..	3,000	
		B, $\frac{3}{10}$ ..	1,800	
		C, $\frac{2}{10}$ ..	1,200	
				6,000
	£22,300			£22,300

The cash received will be used, first, to pay the creditors, secondly, to repay B's Loan account, and, finally, to repay the partners' capitals. The Cash account will then appear:

Cash Account

To—		By—	
Balance	£700	Sundry Creditors...	£10,000
Realization a/c ..	13,600	B, Loan a/c	1,000
		Balance	3,300
	£14,300		£14,300
Balance	£3,300		

The only accounts which have not been closed off at this point are the Cash account and the partners' capital accounts. partners' capital accounts appear as follow:

A—Capital Account.

To—		By—	
Realization %, Plant and Machinery . ..	£2,700	Balance	£8,000
Loss on Realization	3,000		
Balance . ..	2,300		
	£8,000		£8,000
		Balance	£2,300

B—Capital Account

To—		By—	
Loss on Realization	£1,800	Balance	£3,500
Balance	1,700		
	£3,500		£3,500
		Balance	£1,700

C—Capital Account.

To—		By—	
Loss on Realization	£1,200	Balance	£500
		Balance	700
	£1,200		£1,200
Balance	£700		

The credit balances on the accounts of A and B total £4,000 If the debit balance of £700 on C's account is deducted, the net credit balance is £3,300, which equals the balance of cash available for distribution Since C's Capital account is in debit, he must make good the deficiency, and pay in £700 in cash This will enable A and B to be paid in full The closing entries will appear as follow :

A—Capital Account

To Cash	£2,300	By Balance	£2,300

B—Capital Account.

To Cash	£1,700	By Balance	£1,700

C—Capital Account.

To Balance	£700	By Cash	£700

Cash Account.

To—		By—	
Balance	£3,300	A—Capital % ..	£2,300
C—Capital % ..	700	B—Capital % ..	1,700
	£4,000		£4,000

The books of the firm are now closed. One special point must be noted. Had C been insolvent and unable to make good his deficiency, it is clear that A and B could not be paid in full. The question arises: in what proportions would A and B share this additional loss of £700? C's account must be closed, and the Capital accounts of A and B must be debited. In what proportions? The answer is *not*, as one would expect, in the proportions in which they share trading profits and losses, that is, 5 to 3. This ratio is applied for profits and losses upon realization, but not for losses due to the insolvency of a partner. Such losses must be borne in the ratio of the solvent partners' last agreed Capital accounts. It will be observed that A's and B's Capital accounts are in the proportions of 16 to 7. It might, however, be necessary to ascertain the ratio from the last normal balance sheet, prior to the dissolution. In any event, it is clear that this rule, which was first stated in the case of Garner v. Murray, might have a very important bearing on the final distribution of cash between the solvent partners.

In practice, the process of realization may be fairly prolonged, and it is not improbable that, in such cases, the partners may desire an interim payment on account of the capital due to them. Any such interim distribution must be made very cautiously. No payment should be made which might, under possible circumstances, have to be returned, since, if the partner to whom such a payment was made was in financial difficulties, it might be impossible to recover the money. The only way to prevent this happening is to assume that the assets remaining unrealized

will be found to be worthless; that is to say, the greatest *possible* loss on realization must be provided for.

Let us consider the following case of the Balance Sheet of A, B and C:

Capitals, A	.. ..	£10,000		
B	.. ..	8,000	Assets	£20,000
C	.. ..	2,000		
		£20,000		£20,000

Three months after the cessation of business the total proceeds amount to £10,000. Assuming that nothing further will be received, the loss on realization would clearly amount to £10,000 (£20,000 – £10,000).

If the partners share profits and losses in the proportions A $\frac{2}{5}$, B $\frac{2}{5}$, and C $\frac{1}{5}$, the loss on realization would be borne as to A £4,000, as to B £4,000, and as to C £2,000. In this case, C's loss equals his capital, and he would receive nothing. Therefore, in distributing the £10,000 that is available, nothing should be paid to C.

This possible loss on realization would reduce A's capital to £6,000 and B's to £4,000. The £10,000 cash should be divided between A and B on this basis, A receiving £6,000, and B receiving £4,000.

The Capital accounts of the partners will now be:

A, £4,000	(£10,000, less £6,000 cash).
B, £4,000	(£8,000, less £4,000 cash).
C, £2,000	
£10,000	

It will be noticed that the Capital accounts are in the proportions of 2, 2, 1, which is the profit-sharing ratio.

If any further sums are realized, any further interim distributions should be made in the proportions of 2, 2, 1. In this way, no partner will receive a penny which, under any circumsatnces, he can be called upon to return.

Our Course in Accountancy is continued in Volume 5.

LESSON 20

Testing Aircraft Materials

(See plates 1 and 2)

A BREAKDOWN in an aeroplane may have much more serious consequences than one in a car. If the engine of a car stops, the car itself can be pulled up beside the road till the fault has been discovered and remedied But in the case of a similar failure in the air the aeroplane usually, unless it is a multi-engined machine, must come down.

For that reason the greatest possible care is taken to make sure there will be no breakdown Not only are all aircraft materials carefully inspected and passed by a special department of the Air Ministry, known as the Aeronautical Inspection Department, but during the whole time the aeroplane is being constructed it is constantly under inspection. Finally, when it is complete and ready to fly, it is again inspected by the official ground engineer. Nothing, from the engine itself to the very rivets and bolts and nuts, is overlooked The British Aeronautical Inspection Department is one of the most efficient organizations of its kind in the world, and it is due to the constant watch and care it exercises that British aircraft have such a high reputation for safe construction.

Certain specifications for materials are laid down and the materials used in aircraft must be up to the necessary standard. Most metals, for example, have to undergo tests for strength, hardness, ability to bend without breaking, and resistance to blows Special testing machines are used for these tests, and specimens of the metal are selected at random, as they come into the aircraft factory, for testing. In many cases materials are also X-rayed, so that any interior faults can be seen. Any material showing the slightest fault is at once rejected.

Not only are separate parts of aeroplanes tested, but at intervals a whole aeroplane is tested to destruction after it has been built, in order to find out how close its actual strength is to its calculated strength.

The same kind of tests apply to engines. Every new type of engine before it is used has to undergo severe Air Ministry tests, running for many hours at full throttle After these tests they

are dismantled and thoroughly examined for wear and tear. Any engine which comes through these tests successfully can be relied upon not to break down save in very exceptional circumstances. It will give an idea of the standard reached by aircraft engines that they are often run for 100,000 miles or more without being taken down and overhauled. Very few motor-car engines would be capable of such long running without overhaul.

It is impossible to give more than an outline of the tests which are carried out Fig 1 (plate 1) shows a machine which is used for testing the fatigue of metals. Metals get tired just as do human beings. They will often stand up to a big load for a short time, but gradually get weaker under a smaller load over a long time, or a vibrating load, such as comes on the crankshaft of an engine. This gradual giving way can easily be seen in an ordinary bookshelf. The shelf takes a load of books without breaking, but after some months it will be noticed to be sagging. In the machine illustrated test pieces have as many as twenty to thirty thousand alternating loads applied to them, and in other machines as many as a million load reversals are applied to the test pieces.

The Amsler impact testing machine is shown in Fig. 2. In this machine the test piece is subjected to several hundred blows a minute. Many of the moving parts of aircraft engines are constantly being subjected to blows during the whole time the engine is running, and this kind of test enables the engine designer to make sure of the strength of the materials he is using.

A test being carried out on a completed all-metal engine nacelle of a big, three-engined flying boat is illustrated in Fig. 3 (plate 1). The engines used in these big boats weigh half a ton, and when they are running develop considerable stresses in the nacelles containing them. The nacelle is fixed at one end and a gradually increasing load applied at the other by means of chains and heavy levers. Spring balances register the exact load at which the nacelle breaks. In this type of construction, as with the monocoque fuselages described in Lesson 8 (Volume 2, page 12), it is very difficult to calculate the real strength, and the only satisfactory method of discovering it is to carry out a destruction test on a completed nacelle or fuselage.

The way in which a large flying boat is tested for landing in a rough sea is shown in Fig. 4 (plate 2). The assumption is made that the boat lands on two waves—one near the bows and one near the tail—so that for a moment it is unsupported by the

water in the middle, and receives severe shocks at each end from the impact of landing. This is one of the worst things which can happen to a flying boat The loads are applied to the hull under test by means of powerful screw jacks and levers It may appear costly to carry out such kinds of tests, but the cost is very little compared to the amount saved by finding out in this way the right type of construction, and so saving repairs after building *Seaplane floats are tested in a very similar way*

A test being carried out on a metal built-up spar is illustrated in Fig 5. How the spar behaves under steadily-increasing loads until it actually breaks is carefully noted, so that it can be judged how it will behave under the forces coming on it in various manoeuvres. This type of testing machine will take spars up to 100 feet in length and apply loads to it up to 100 tons. In a similar way ribs and whole wings of aircraft are tested, tail planes and controls, and so on. No part is overlooked to make British aircraft the safest in the world. Petrol tanks are dropped from heights and tested in other ways to find out how easily they burst, and from these tests tanks have been evolved which will remain whole even after a severe crash and so lessen very considerably the chance of fire. All new types of landing wheels are tested to destruction to find out for what weight and type of aeroplane they are most suitable.

There are many other tests carried out besides those of the actual strengths of the materials used—tests to show the way the aeroplane will behave in the air, or a seaplane or flying boat on the water. These tests are described in Lesson 24.

LESSON 21

Aerodromes and Their Equipment

(See plates 3—6)

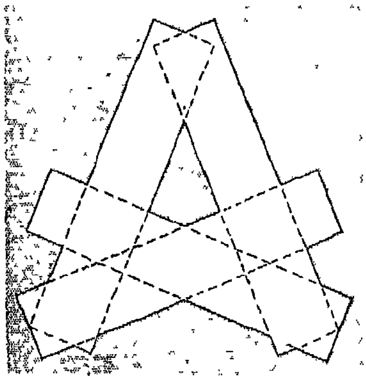
THE time is rapidly coming when properly designed and *equipped aerodromes* will be almost as common as railway stations. The design, equipment and staffing of the number of aerodromes which will be in existence will require a very large personnel, and will offer a new scope for employment which is only at the moment in its infancy.

Many people have an idea that any large field with a reasonably smooth surface is good enough for an aeroplane to land on, and

any suitably sized shed good enough to serve as a hangar. Nothing is less true. The rapid increase in air traffic and in travel by night calls for the most careful aerodrome designing.

From the point of view of the surface and the size of the area chosen, a site might appear ideal But there are other considerations which have to be taken into account—the nature of the surrounding country, the general type of weather, the possibility of expansion of the town the aerodrome proposes to serve, and so on It would be of little use choosing a fine space of ground, for example, in a district which was notorious for its fogs. And any place selected must have easy road or rail facilities.

Landing Surfaces. Aerodromes for public use must be licensed in this country, and they must be of a certain minimum size, in order to give an aeroplane a clear run in all directions for getting off or landing For larger types of aeroplane the *landing ground must not be less than 800 yards in any direction*, and preferably 1,000 yards. The surface of the aerodrome usually consists of grass intersected with concrete runways for getting off and landing on. A grass-grounded aerodrome is quite suitable for small aeroplanes, but not for large commercial air liners weighing many tons and landing or getting off at high speeds.



AERODROME DESIGN. Fig. 1. Diagram of simple pattern consisting of three concrete runways.

Courtesy of The Royal Aeronautical Society

The ideal method, of course, is to have a completely concrete surface, but this is not usually possible on the score of expense. If the concrete runways are properly arranged, however, an aeroplane can land or get off into the wind, or almost into the wind, in whatever direction it may be blowing. Fig. 1 shows a simple runway pattern which has been adopted in some airports and only requires three runways. This pattern enables the control tower, hangars and other buildings to be conveniently placed for the arrival and departure of aeroplanes and passengers.

Airport Buildings. The airport or aerodrome buildings are as important as railway station buildings, and have to be designed not only from the point of view of comfort but of easy access to the waiting aeroplane. In bad weather passengers must step straight into the shelter of a building and not be called upon to cross the aerodrome. In America, where passenger flying has developed on a very large scale, this is recognized, and the aeroplane can either taxi right into one of the buildings, or covered-in gangways can be run out across the intervening space between the waiting aircraft and the building, and so protect the passengers. Accommodation at all modern aerodromes must provide for administration and staff, passengers, and the public which wishes to watch the arrival and departure of aeroplanes.

A view from the air of the airport at Croydon is shown in Fig. 2 (Plate 3). This is one of the customs airports where all passengers arriving from the Continent have to declare their luggage in just the same way as at an ordinary customs port. There is an hotel in connexion with the airport and the control tower, an enlarged view of which is shown in Fig. 3 (Plate 4), can be seen in the buildings on the left. To the right are the hangars, and to the left the passengers' waiting-rooms, customs room, etc. Sweeping round to the right can be seen the concrete runways or aprons, as they are known, leading to the hangars.

The Control Tower. From the control tower, which every big aerodrome or airport has, all aircraft entering or leaving are signalled in and out by the control officer. At Croydon, for example, no aeroplane is allowed to land until it receives permission to do so, or it may collide with some other aeroplane getting off. There are international rules for the way an aeroplane shall approach an aeroplane or pass other aeroplanes, and with increasing air traffic it becomes highly necessary that these rules shall be strictly observed. In the control tower the latest weather reports are received and broadcast by wireless to aeroplanes, and from the control tower constant touch is kept with the big passenger liners flying along the air routes. Any air liner flying between Croydon and Paris, for example, can call up Croydon from the air anywhere along the route and ask for information which the pilot requires, or give Croydon warning of any special difficulty in flying or particulars of local weather. Fig. 4 shows the interior of the control tower of one of the United States aerodromes, Wayne, Indiana. It will be noticed, as in

the case of all control towers, it has a glass roof and sides, so that the control officer has no difficulty in seeing in all directions. Fig. 5 (Plate 5) gives a close-up view of the hangars and concrete apron at the famous Roosevelt Field aerodrome, and Fig 6. shows the modern type of airport building at Brooklands, Surrey.

Methods of Lighting. The aerodrome and airport of the future will be used day and night just as railway stations are. Already there are many thousands of miles of lighted airways throughout the world, and more routes are being lighted for night flying every year. Every aerodrome used at night has to be outlined with boundary lights, and lights are placed on every obstruction. Mobile and fixed flood lights are used to light up the surface of the aerodrome for night landing. The fixed lights often include flush lighting along the runways. These flood lights are constructed to eliminate dazzle.

An important part of the lighting is the airport beacon, usually of a rotating or flashing type, and very similar to a lighthouse beacon. These airport beacons flash a given code by means of which the aerodrome can be recognized. Wind indicators are also illuminated, so that the pilot can see at night in which direction to land. Fig. 7 (Plate 6) shows a standard airway beacon and Fig. 8 a rotary reflector beacon. Many major airports have now installed Lorenz type blind approach and landing beacons

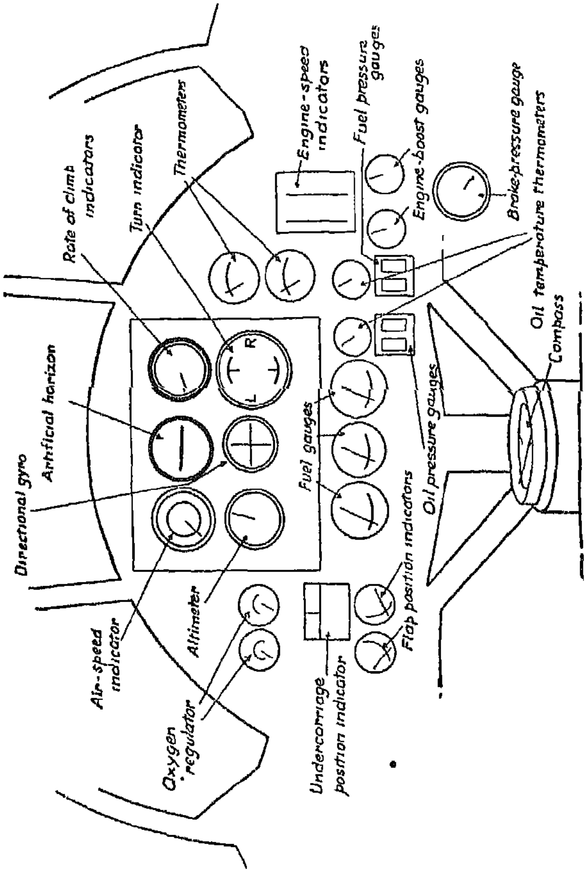
LESSON 22

Engine Instruments

(See plates 6 and 7)

CERTAIN instruments are necessary on an aeroplane not only in order to indicate to the pilot whether his engine is running properly or not, but to tell him that he is flying properly. In general terms there are three sets of instruments on the dashboard in front of him: (1) engine instruments, (2) navigation instruments, and (3) flying instruments. Fig. 1 shows diagrammatically the instrument board of the Handley Page Hampden used in the Royal Air Force, and gives an

mum of 654 gallons; instruments are used to indicate the amount of fuel in each tank. Many other instruments must of necessity be duplicated.



AEROPLANE INSTRUMENT BOARD. **Fig. 1.** This diagram of the board on a bombing aeroplane shows the recording instruments installed in an R.A.F. machine.

Royal Air Force Official: Crown Copyright reserved

There has been a tendency to place too many instruments on the dashboard in order to increase the safety of flying. But with the steady improvement in the aeroplane itself the number of

instruments may lessen, and in some cases certain instruments are being combined together, so that one reading on the dial gives the pilot all the information or warning he wants.

One of the most important of the engine instruments is the engine revolution indicator, which tells the pilot the rate of revolution of the engine crankshaft. It is important, because it warns the pilot when there is a falling off in the speed, and so the power of the engine, upon which the whole of his flying and manoeuvring ultimately depends. By watching the indicator the pilot is able to prevent the engine "over-revving," which may cause disaster, and to see that it is properly run up on the ground before he takes off for a flight.

There are many types of engine revolution indicators. In the centrifugal type the ordinary principle of the Watt governor fitted to stationary engines is used The accuracy of these instruments is of a very high order. They will, for example, indicate the revolutions of an engine running between 600–2,600 revolutions per minute to within twenty revolutions. When a number of engines are used, as in large aeroplanes, a large dial is often fitted on each engine nacelle. This can be read from the pilot's cockpit, and lessens any inaccuracies which might arise by fitting the instrument on the dashboard and using a long, flexible driving shaft. Fig. 2 (Plate 6) shows a typical engine revolution indicator as used in the Royal Air Force.

On British commercial aircraft a chronometer type of indicator is used. This type measures the revolutions during successive time intervals of definite length. Fig. 3 shows one of the best-known of these instruments, the Tel engine-speed recorder. At the top of the instrument will be noticed the automatic chart which records the speed of the engine during the whole of the journey made by the aeroplane. Various electric types of indicator are in use, but at present they have certain disadvantages which make them less practical than the centrifugal and chronometer types. Other types, depending upon the fluid pressure produced by a pump driven by the engine, are also used, but they have the disadvantage of not always indicating, as rapidly as other types, quick changes in the speed of the engine, though in general working they are very reliable.

One of the difficulties in flying is to indicate the depth of fuel in the petrol tanks. An aeroplane moves at a very high speed, and there is a constant swirling of the petrol in the petrol tank.

As aeroplanes, too, fly under great variations of height and temperature, any instrument measuring the amount of petrol has to take these factors into account. Most of the fuel indicators used are similar to those employed on motor-cars, but are not usually accurate enough for aeroplane work. Three fuel contents gauges are shown on the instrument board in Fig. 1 to indicate the level of the petrol in the three main tanks. There is also a gravity tank overflow indicator.

Another important instrument is the pressure gauge, used to indicate the pressure of the fuel supply and the oil. These gauges, like all other instruments, have to work under wide variations of temperature and height, and must be proof against vibration. The oil pressure gauge on the dashboard may be at some considerable distance from the engine, and this creates a difficulty in accurate measurement of the pressure, since the oil cools and thickens in a long connecting pipe. The difficulty is got over by filling the connecting tube with a non-freezing liquid, the oil pressure being transmitted to the mixture by means of a flexible diaphragm. Fig. 4 (Plate 7) shows the Amyot gauge.

The overheating of an engine in an aeroplane may have a very serious effect. Thermometers are used for indicating not only the temperature of the oil and the water in the radiators, but also atmospheric temperature. They are all required to safeguard the pilot against overheating the engine and boiling the water in the radiator; overcooling the engine and freezing the water; and overheating and overcooling the oil. An air temperature thermometer is necessary to obtain corrections for the height-recording instruments, or altimeter.

LESSON 23

Flying Instruments

(See plate 7)

THE air speed indicator measures the speed of the aeroplane in relation to the air through which it is moving. It does not, save in exceptional circumstances, measure the speed of the aeroplane relative to the ground below, a fact which cannot be over-emphasized. The air speed indicator, for example, may show that the aeroplane is moving at 120 miles an hour through the air. But if there is an adverse wind

of, say, 20 miles an hour, the actual speed of the aeroplane over the ground will only be 100 miles an hour. The actual ground speed, as it is called, cannot be measured directly by any instrument, and has to be calculated in various ways.

The most common form of air speed indicator is the one known as the Pitot tube. It consists briefly of two tubes so arranged that the pressure in one varies as the speed of the aeroplane, and in the other is independent of that speed. Between the tubes is a diaphragm connected to a pointer, and as the diaphragm is distended by the difference in pressures, the needle moves over a dial and so records speeds. The Pitot tube is usually mounted on one of the struts of the aeroplane.

As the principle of the instrument depends upon pressure, and as the density of the atmosphere varies with height and temperature, the air speed indicator is only accurate at one height and one temperature; it must therefore be corrected for others. It is usually correct for readings at ground level, and consequently reads too low a speed as the height increases. The speed may be calculated by means of an instrument known as the Appleyard air speed computer, or by multiplying the indicated speed by a constant. Fig. 1 (Plate 7) shows the dial of the Smith air speed indicator.

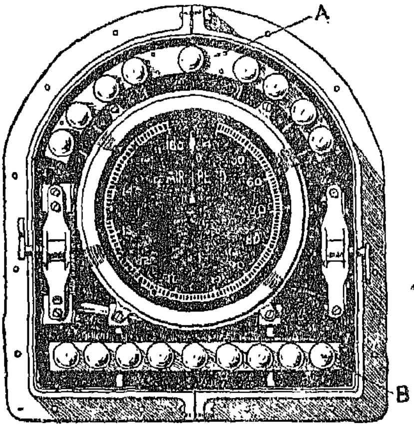
Altimeter. The altimeter is another important instrument carried by aircraft It gives the approximate height of the aeroplane above the ground. Many altimeters have an adjustable zero mark, so that the height is given above this zero. It may be the height above sea level or the height above the place of departure. Usually it is set as for sea level.

The reading of an altimeter varies with temperature and height, and the reading may be given above or below the real height the aeroplane is above the ground. The principle of the altimeter is that of the ordinary aneroid barometer, giving readings in heights instead of variations of atmospheric pressures.

The failure of the normal altimeter to record height within the limits of accuracy required for flying has led to the development of other methods, of which the most promising is the acoustical one. Briefly this method consists of an instrument which gives the time taken for an echo of a sound from the aeroplane to the ground to be received.

Turn and bank indicators, as their names imply, are instruments for indicating the direction in which an aeroplane is turning

and the amount which a machine is banked during the turn. If an aeroplane is not banked sufficiently when turning it will sideslip. There are many types of turn and bank indicators, one of the best known being the Reid. This combines the functions of both instruments and also that of an air speed indicator. Red and green lights are used to indicate the amount of the turn. Fig. 2 shows the instrument with the cover removed. The top row of lights A is controlled by the mercury in a U-tube, which, by making contact between wires fused in the U-tube, lights up one or more of the lamps. The U-tube is the equivalent of the ordinary bubble or spirit level carried in some aircraft, and tells the pilot whether his aeroplane is flying level or not, so warning him he is turning. The lower lights B are controlled by a small gyroscopic wheel. The lights go up according to the rate of turn and its direction, so that the pilot has clear and visual warning of how he is turning.



TURN AND BANK INDICATOR. Fig. 2. Interior of a Reid indicator, employed to show the angle of the aeroplane when banking during a turn (*see text*).

From C. J. Stewart, "Aircraft Instruments," Chapman & Hall

Compass. *The compass is the most important instrument* carried by aircraft, and is necessary for navigation over long distances where the ground below is either not visible or the landmarks are unknown. The magnets in aircraft compasses are supported in liquid. All aircraft compasses are subject to errors, partly due to the fact that they are being carried in fast-moving aeroplanes, partly due to the earth's magnetism, and partly due to the metal in the aeroplane.

If an aeroplane is on a banked turn heading towards the magnetic north the compass card will move in the same direction as the aeroplane. Sometimes, in fact, the card will move faster

of, say, 20 miles an hour, the actual speed of the aeroplane over the ground will only be 100 miles an hour. The actual ground speed, as it is called, cannot be measured directly by any instrument, and has to be calculated in various ways.

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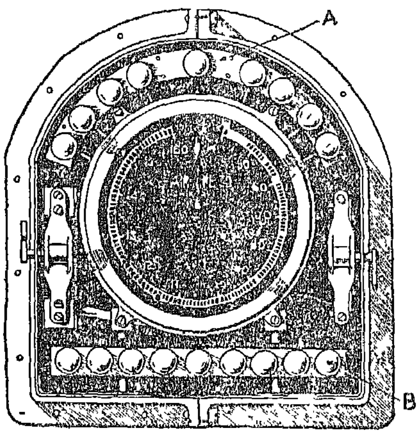

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than the aeroplane, and will appear to indicate that the aeroplane is turning in the opposite direction to which it actually is. This is known as the Northerly Turning Error. It was this error which frequently caused a pilot to lose all sense of direction in clouds and go into a spin The compass is also affected by the way a machine is flown, even on a straight course, as the aeroplane in the best of circumstances oscillates slightly from side to side. What is known as the aperiodic compass has lessened considerably the errors of the ordinary compass, and such compasses are now used in most aircraft. Fig. 3 (Plate 7) shows the 6/18 Mark III aperiodic compass made by Messrs. Henry Hughes and Son, Ltd

The earth inductor compass, an American invention, is a type of aircraft compass coming widely into use, as it offers many advantages over the ordinary magnetic compass. It has been largely used on long-distance flights. In modern aeroplanes, built of metal, the ordinary compass may be so affected that it becomes unreliable. The earth inductor compass has an electric generator which determines the direction and corresponds to the needle in a magnetic compass. Fig. 4 shows the earth inductor compass. Any deviation from the course is shown on the indicator.

For long-distance navigational purposes certain other instruments are often carried to enable quick calculations to be made. They are chiefly instruments, like the Addison Luard course calculator and wind calculator, for solving automatically the trigonometrical problems involved. The bearing plate and drift indicator is used to obtain the speed at which the aeroplane is moving over the ground and the way it may be drifting out of its course owing to a cross wind.

Navigation by wireless directional finding will probably be one of the best methods of air navigation in the future. It involves the use, however, of rather heavy apparatus, making it unsuitable at present for light aircraft. For large aircraft it is already in use, and works very much on the same principles as the ordinary portable wireless receiver with a frame aerial. But wireless direction finding is only an additional help for navigation, and will not supersede the various instruments which have been described, though it will make the task of navigation, especially over considerable distances, along recognized air routes provided with wireless transmitting apparatus, appreciably easier.

LESSON 24

Research Work

(See plates 8 and 9)

It was explained in Lesson 20 (page 39) how every part of an aeroplane or flying boat is most carefully tested to make sure that only the very finest materials are used and that the aircraft is correctly built. But the actual construction of an aeroplane is only one part of the work which has to be done. However carefully an aeroplane may be built there is still the fact that it is meant to fly. To make sure, *before it is built*, that an aeroplane will not only fly, but will be safe to fly, will fly at a certain speed and land at another, will carry the load it is intended to carry, and will be able to do the hundred and one other things the designer is called upon to make it do, is an entirely different kind of problem to solve. It would be much too expensive and much too dangerous to build aeroplanes which it is thought will fly, and then experiment with them. That was the method of the early days of flying, and many pioneers were killed and many aeroplanes destroyed finding out things which are now found out far more simply.

It is vitally necessary to know what forces an aeroplane has to withstand when flying. These forces are due to the pressure of the air on the wings, and the control surfaces, e.g. the rudder when the aeroplane is turning, and an aeroplane has to be designed so that it can withstand them when in the air.

Now these forces are the same whether the aeroplane is moving through the air at a high speed, or whether the aeroplane is stationary and the air is caused to move past it at high speed. On this fact depends the whole of modern aeronautical research, which has done so much to make flying safe. There is another important discovery which has also helped to make possible investigations into the behaviour of aeroplanes. This is that a model of an aeroplane behaves in the same way as the full-sized aeroplane.

Wind Tunnels. These two discoveries have led to the most powerful instrument of research in aviation, the wind tunnel. The wind tunnel is an apparatus, shaped in the form of a tunnel, for producing a steady stream of air in which models of aircraft

or of any parts of aircraft, e.g. the wings or the wheels or the body, can be suspended and the forces which come on them directly measured. All over the world wind tunnels are in constant use measuring everything that is required for making aircraft safe to fly. In these wind tunnels every shape of aeroplane wing is tested, new types of aeroplane—in model form—are examined, and all the manoeuvres to which an aeroplane is subject are faithfully imitated.

There are various types of wind tunnel. In the type most used in Great Britain the air is driven by fans through a complete tunnel in which the models are suspended and viewed through glass walls. This is known as the closed type of tunnel. In the other type, known as the open jet tunnel, the tunnel has a gap in it and the models are tested in the air jet which flows across the gap. Fig. 1 (Plate 8) shows a photograph of one of the large tunnels used at the National Physical Laboratory at Teddington, and Fig. 2 an aeroplane model being tested in the tunnel.

These aeroplane models have to be very accurate, and highly *skilled workmanship is necessary. So accurately, in fact,* are they made to scale that the errors are never more than two to three-thousandths of an inch. Care has to be taken as the results which are obtained have to be multiplied by a factor which depends upon the actual speed of the air and the relative size of the model to the full-sized aeroplane. To put it in mathematical language, the forces on two bodies which are geometrically similar are proportional to the squares of the wind speeds and the squares of their sizes. Thus, if we measure in the wind tunnel the forces on a model which is made one-fifth the size of an aeroplane, and the speed of the air through the tunnel is half the speed at which the aeroplane will fly, then the forces on the actual aeroplane are found by multiplying the corresponding forces measured in the wind tunnel by the square of 5 and by the square of 2, that is, 25 times 4, i.e. 100. There are certain other effects which have to be considered, e.g. the density of the air. By using compressed air more accurate results can be obtained. It is obvious, too, that the larger the model and the higher the speed of the air through the tunnel, the more accurate are the final results, as the factor by which these results have to be multiplied becomes less.

Compressed air wind tunnels have been built in Great Britain and the United States having wind speeds of 90 feet and 70 feet

per second respectively. The atmospheric pressures are very great—25 atmospheres in the case of the British tunnel and 20 in the American.

In small tunnels one of the difficulties which have to be faced is the interference effects of the walls of the tunnel, making the air flow uneven, for example. In 1922, in America, a large tunnel, with a jet of air 20 feet in diameter, was built to test full-sized airscrews, and this was so successful that a still larger tunnel was built with a jet of 60 by 30 feet. In tunnels of this description full-sized aeroplanes can be tested with no danger to the pilot or risk of damage to the aeroplane. To give only one instance of their value, by the use of such a large tunnel the maximum speed of an aeroplane was increased by 20 miles an hour, and the saving in petrol alone on this particular type of aeroplane paid the cost of the tunnel many times over. A 24-foot tunnel has now been built in the government research establishment at Farnborough, and the jet has a speed of 120 miles an hour.

One of the newest and most remarkable types of tunnels is the vertical wind tunnel at Farnborough. In this tunnel the air jet is vertical, and aeroplane models fly freely round in it. The speed of the air is adjusted so that the aeroplane neither rises nor falls. The models are fitted with controls, exactly like those in the full-sized aeroplane, and by an ingenious mechanism these controls can be altered on the model as it flies round, so that spinning and other manoeuvres can be imitated.

Testing Tanks. For seaplanes and flying boats the water tank is used. The floats of seaplanes and the hulls of flying boats must be of the correct shape for landing on and getting off the water, and these shapes are tested in the water tank. The models are suspended from a travelling carriage, on which sit those who are observing the behaviour of the model. Fig. 3 (Plate 9) shows the water tank used by Messrs. Short Brothers, the well-known flying boat builders. The seaplane tesring tank in use at Farnborough is 600 feet in length and 9 feet wide, while the chief one in the United States is 24 feet wide and 2,000 feet in length.

Many other methods are in use to test the possibilities of ideas in flying, and Fig. 4 shows one of them, the whirling arm at the National Physical Laboratory. This enables circular flight to be studied, the model being suspended at one end of the arm, the speed of which can be regulated.

LESSON 25

Aviation as a Career

THERE are many and increasing opportunities for those who wish to enter aviation The aeronautical industry is going to be one of the greatest industries in the world, and, this being so, it will call for the employment of a very large number of people.

Aviation can be roughly divided into the following parts: (1) Manufacture of materials and accessories; (2) Design of aircraft, aircraft engines and parts; (3) Manufacture of aircraft, aircraft engines and parts; (4) Erection of aircraft and aircraft engines; (5) Testing of aircraft and aircraft engines; (6) Piloting; (7) Navigation and wireless; (8) Commercial and office organization; and (9) Research work.

Under (1) there are included all firms manufacturing metals, fabrics, dopes, paints, glues, and all other materials, as well as the accessories used in aircraft construction. A list of the approved makers of aircraft materials and accessories is given in the British Air Annual, and application should be made direct to the firm concerned.

Under (2) there is called for a high degree of theoretical and practical training. A designer of aircraft or aircraft engines should have an engineering degree if he wishes to make any progress, for without a sound engineering degree he stands very little chance of advancement. He can, alternatively, take the examinations of the Royal Aeronautical Society, which are of engineering standard and are recognized by the aeronautical industry as a qualification for a post. It must be emphasized that upon the designers depends the safety of aircraft, and for that reason alone designers must be fully qualified. Most aircraft designing firms will start a man with such knowledge as a junior draughtsman, and for qualified men there are a number of posts open in the Air Ministry. Particulars should be obtained direct from the Under-Secretary of State, Air Ministry, King Charles Street, Whitehall, London, as the regulations vary.

As regards (3) the manufacture of aircraft, aircraft engines, and parts is largely workshop practice, and anyone wishing to enter

this branch should apply to one of the manufacturing firms, either as a shop boy in the first instance or as an apprentice in the workshops.

Aircraft fitters and erectors, who come under (4), have almost always had some experience at the work bench and in the manufacture of aircraft or aircraft parts. Nevertheless, the duties of an erector are specialized ones, and he has to put together the parts made in the workshops and erect them into the complete aeroplane.

Ground Engineer. Into this category comes the ground engineer, whose work it is to see that aircraft and aircraft engines are fit to fly, and who has to have licences to show that he is qualified. There are five kinds of ground engineers' licences—A, B, C, D and X licences.

The A licence certifies that its holder understands the general principles of systematic maintenance and examination of aircraft before flight. He has to have a knowledge of the rigging of an erected aircraft, the adjustment of flying controls, the various materials used in aircraft, and so on. The B licence holder inspects aircraft after overhaul, and has to have considerably more knowledge of materials and their testing, of the construction and installation of engines, controls, instruments, and the like.

For (5), the inspection of aero engines before flight, a C licence is required. The holder must have a general knowledge of the construction of a particular type or types of engines for which the licence is granted. He must be able to carry out a general top overhaul, and know what defects are likely to be encountered and the permissible allowances for wear and deterioration. He must also have a knowledge of methods of inspecting and testing the installation of engine instruments, engine revolution indicators, pressure gauges, and the like.

The holder of a D licence can carry out the inspection of aero engines after overhaul, and he requires considerably more knowledge than the holder of a C licence. He must have a knowledge, for example, of the materials used and their testing and manufacture. He must know the general principles of testing and measurement of the horse-power, fuel and oil consumptions, etc., of aero engines, and the correct functioning of ignition, carburation, lubrication and cooling systems on engines during tuning up and testing. C and D licences are usually granted for specific engines and not for aeroplane engines as a whole.

X licences are issued in respect of the following duties: (1) repair, overhaul and testing of magnetos; (2) repair, overhaul, testing and calibration of aircraft and aero-engine instruments; (3) inspection, packing and maintenance of parachutes; and (4) adjustment, installation and compensation of compasses in aircraft.

Every ground engineer is required to pass an examination at the Air Ministry, and to have had practical experience before his licence is granted. Full particulars of the ground covered for each licence and the times of the examinations may be obtained from the Air Ministry, Kingsway, London

Wireless operators sometimes enter aviation fully trained, after having obtained their experience either at sea or with a wireless telegraph company Anyone who wishes to become a wireless operator in aircraft should apply to such a company and obtain his experience on land or water in the first place.

Seamen who hold a mate's or master's ticket will have little difficulty in obtaining an air navigator's licence. Otherwise, it is necessary to pass examinations for the licence, particulars of which may be obtained from the Air Ministry or the Guild of Air Navigators and Pilots.

In general, it may be said that for anyone to obtain a post in the aeronautical industry with any hope of advancement he or she must be qualified in some way or other, and, in general also, that these qualifications are higher than those required for corresponding posts in other forms of engineering. A mistake may cost a man his life; and the whole aim of the regulations governing the construction and flying of aircraft is to eliminate, so far as possible, the chance of error.

There is an opening for research workers in aviation, but such workers are usually highly qualified, holding a University degree and specializing in some branch of aeronautics, as aerodynamics. Knowledge of the behaviour of the air and of the behaviour of bodies moving through it at high speeds is still in its infancy, and here the research worker has the greatest opportunities.

There are posts open on the commercial and office organization side of aviation, which do not call for any particular experience to begin with, apart from the usual qualifications of shorthand and typewriting and languages. A knowledge of languages is an important asset. Application should in every case be made to one of the aeronautical firms direct.

LESSON 26

Careers in the Royal Air Force

One of the best ways for a young man to enter into aviation is by joining the Royal Air Force. If he has the necessary education and fulfils other requirements, he can apply for a cadetship. On the other hand, he can enter the Royal Air Force as an air mechanic or, if he passes the necessary examination, as a boy apprentice, and if he seizes his opportunities he has the highest roads of the Royal Air Force open to him.

Several hundred aircraft apprentices between the ages of 15 and 17 are required by the Royal Air Force every year for entering into the schools of technical training at Halton, Bucks, and Cranwell, Lincs. They are admitted partly by competitive examination and partly on presentation of an approved first school certificate. The sons of officers, warrant officers and senior N.C.O.'s in all three fighting services receive special consideration.

Successful candidates serve twelve years from the age of eighteen. At the age of thirty they are given the opportunity of serving for another four years in the R.A.F. reserve and of drawing a gratuity (at present £100). A certain proportion, which varies from time to time, can re-engage to complete a full period of service for a pension

Training of Apprentices. Aircraft apprentices have splendid opportunities of a three years' apprenticeship course. The skilled trades at present open are those of fitter, fitter (armourer), wireless operator-mechanic, and instrument maker These are the most important in the Royal Air Force. During the training period, which is very thorough, the present rate of pay is 1s. a day for the first two years and 1s. 6d. a day thereafter, until the apprentice has reached the age of eighteen and also been posted to a unit on completing his apprenticeship training. When he is posted to a unit for duty as an aircraftman the commencing rate of pay is 3s. 9d. to 5s. 6d. a day, according to the marks obtained in the passing-out examination. He also receives free board and lodging and an allowance for uniform. A number of apprentices each year who have shown special promise in their

examinations, etc., are given free cadetships at the Royal Air Force College for training for commissioned rank. Every year a considerable number can volunteer and qualify to become airmen pilots, and these have opportunities each year of being selected for commissioned rank.

An aircraftman, when he leaves the Royal Air Force, does so with excellent knowledge of a trade at which he should be able to earn his living on return to civilian life. Many aircraft firms employ ex-aircraftmen because they are certain of so obtaining properly-trained men. Anyone who enters as an aircraft apprentice at Halton or Cranwell, in fact, can, if he wishes, acquire a technical knowledge of aviation and a wide practical experience which no other method offers him.

Short Service Officers. Candidates who wish to serve in the Royal Air Force as officers usually apply for a short-service commission in the general duties branch, which includes flying, technical and general administrative duties, and the equipment and accountant branches, but not medical, stores, and a few other duties.

Candidates for a short service commission must have reached 17½ years of age, and not 28 years, when they apply. Qualified pilots of the Volunteer Reserve for the Auxiliary Air Force may apply. Every candidate must be unmarried and be up to school certificate standard in education. Candidates are interviewed personally and have to pass a medical examination. Short service officers are appointed for a period of four or six years on the active list and six or four on the reserve. They are appointed in the first place as acting pilot officers, and are on probation until the appointment is confirmed. Observer officers are also appointed from time to time.

Permanent Commissions. A number of permanent commissions are awarded annually to officers holding short service commissions. The majority of these commissions are awarded to those officers who have specialized in engineering, photography or armament. There are competitive examinations for permanent commissions.

The current rates of pay are from £340 per annum for acting pilot officers up to £787 for squadron leaders after five years' service. Certain extra allowances are given to officers who are married. Officers holding short service commissions are given facilities by the Royal Air Force Educational Service to prepare

themselves for a civil career on completion of their service, and the Air Ministry keeps contact with employers and recommends those who have good records An officer transferred to the reserve is entitled to a gratuity of £300 or £500

Candidates for permanent commissions enter through the Cadet College at Cranwell Admission to the college is granted to (1) successful competitors in the Royal Air Force entrance examinations, which are held twice yearly, (2) King's cadets and Honorary King's cadets, i e the sons of officers killed or died of wounds received in action, etc, (3) candidates specially nominated by the Air Council, i e from certain approved schools or from midshipmen or naval cadets, (4) aircraft apprentices as stated above The limits of age generally for admission to the college are from 17½ to 19½ years

Every candidate has to undergo a rigorous medical examination The course at the cadet college lasts two years and the total cost is approximately £250 There are reduced fees in respect of a father's service in one of the fighting forces

Pay for officers in the Royal Air Force varies from £389 per annum for a pilot officer up to £2,847 for Air Chief Marshal Married officers receive a small increase in pay Any candidate for the Royal Air Force should obtain a copy of the full regulations from the Air Ministry

In addition to the military side of the Royal Air Force a number of civilian appointments are made to it and to the Air Ministry and the various establishments connected with it—scientific and technical officers, A I D inspectors and so on There is also the department of civil aviation which offers certain posts

With the rapidly increasing use of aerial transport and of the Royal Air Force the prospects are extremely bright but the standard required in aeronautics is extremely high

The following books are recommended for further study in aeronautics "Flight Handbook," W O Manning (Iliffe & Sons), "The Book of the Aeroplane," J L Pritchard (Longmans, Green & Co), "Air Sense" W O Manning (Pitman), "Aeroplane Structures," A J S Pippard and J L Pritchard (Longmans, Green & Co), "Internal Combustion Engines," D R Pye (O U P), "Elementary Applied Aero dynamics" T G Whitlock (O U P), Handbook of Aeronautics (Royal Aeronaut

LESSON 19

Influence of Pre-Raphaelites on British Painting

(See plates 10 and 11)

TOWARDS the middle of the 19th century, portraiture was almost at zero, and subject pictures by the popular artists, Landseer, Leslie and Frith, were sentimental, theatrical or trivial. The necessary art revival came with the pre-Raphaelite Brotherhood, but just before that movement George Frederick Watts (1817–1904) and Alfred Stevens (1817–1875) had begun their careers. Both of these artists remained outside the pre-Raphaelite movement, and both were influenced by Greek sculpture and Italian painting—Watts by the great Venetian colourists and Stevens by the masters of the Renaissance period. Watts, having gained a premium for a cartoon for the decoration of the palace of Westminster, studied in Italy, and from the time of his return to England, in 1847, became one of the most noted artists of his day. His famous series of portraits of the intellectual leaders—John Stuart Mill, Carlyle, Cardinal Newman, Tennyson, Matthew Arnold, Gladstone and others—with the gift of which he enriched the National Portrait Gallery, London, prove him to be a great painter, though his symbolic pictures are less popular today. He was an artist of great sincerity, versatility and industry; he possessed—though he used them unequally—both the gift for grand design and the mastery of technique. "Time, Death and Judgment" (Millbank) and "Love and Death" (Millbank) are among his finest symbolic pictures, most of which are powerfully imaginative in conception, showing forth the strangely mingled agnosticism and faith which composed Watts' religion. He painted many good landscapes, but achieved only transient success as a sculptor.

Alfred Stevens, on the contrary, was a sculptor of genius. He was also an excellent painter and a faultless draughtsman. While studying in Italy, he worked under the Danish sculptor Thorwaldsen, and on his return designed, amongst other decorations for public buildings, the four mosaics of the Prophets

for the dome of St Paul's He was unable himself to complete his greatest work—the monument of Wellington in St Paul's—owing to lack of means and the magnificence of his conception, it was finished from his model thirty-seven years after his death In addition to his many lovely cartoons—notable among the latter being those for Dorchester House—he painted some excellent portraits, a fine example of which is Mrs Collmann (Millbank) Frederick, Lord Leighton, Sir Edward Poynter and many other painters in the classical style, whose work was profusely exhibited during the nineteenth century, never attained the level of Stevens' art His classicalism was inherent, and no mere imitation of the ancient Greek sculptors or the Italian masters of the Renaissance

The originators of the pre Raphaelite movement, William Holman Hunt (1827–1910), Dante Gabriel Rossetti, the painter-poet (1828–1882), and John Everett Millais (1829–1896), determined at the outset of their careers to substitute romance and poetry for the trivial subjects of pictures by most of the popular artists of the day They desired to shake themselves free of traditions which had mainly degenerated into superficial presentments of academic art They set out to revive the humble and conscientious attitude towards Nature which had characterized the work of the Italian Primitive painters In 1849, a year after the pre Raphaelite Brotherhood was established, its three members exhibited their first representative P R B pictures "Rienzi," by Hunt, "Isabella and Lorenzo," by Millais (the subject selected from Keats' poem "Isabella and the Pot of Basil"), and "Girlhood of the Virgin," by Rossetti

Though these first pictures received some favourable criticism, abuse was soon directed against the P R B The very name for which these initials stood was obnoxious to academic critics who considered Raphael the greatest of all painters and the Primitives of comparatively little interest So bitter was the attack on Rossetti's beautifully designed picture, "The Annunciation," exhibited in 1850, that he never publicly showed his work again during his lifetime, while the pictures exhibited by Hunt and Millais, at the same Academy Exhibition, fared little better In strenuous opposition to the new movement was Charles Dickens, who wrote a scathing article in his magazine "Household Words" Swiftly defensive appeared Ruskin's letters in "The Times," demanding fair play for the youthful

painters and pointing out the value of the revival of the earnest medieval spirit.

Holman Hunt was the only one of the pre-Raphaelites—into whose circle also came Ford Madox Brown, William Morris and Edward Burne-Jones—to paint unswervingly throughout his career within the laws laid down by the youthful aspirants. Hunt was a man of powerful individuality and strong religious convictions, which influenced his work. His faults were a certain rigidity in the posing of his figures, a superabundance of detail and crudity in the colours he used—the results of painting everything as he knew it to be rather than as he actually saw it. These faults were overcome in some of his work, notably in "The Hireling Shepherd" (Manchester City Art Gallery) and in "Claudio and Isabella" (Millbank). Many of his pictures reveal great beauty of design—for example, the "Triumph of the Innocents" (Millbank) and "The Scapegoat" (Port Sunlight)—but require to be studied in detail for true appreciation of his genius.

Millais' most successful pictures in the P.R.B. manner are his "Ophelia" (Nat. Gallery), "The Blind Girl" (Birmingham Art Gal.), and his realistic "Christ in the House of His Parents" (Millbank). A peculiarity of this artist's work—though not originated by him, as he adapted it from the Flemish masters—was his method of painting with transparent pigment over a white groundwork; this accounts for the brilliant richness of the resultant colour. He cannot be regarded as an inspired painter; possessed of far greater facility than Hunt, Millais' work was more popular, but is unquestionably of less importance. In the 'sixties he was largely concerned with book illustrations, with which he achieved real success. His later paintings were marred by dullness, due to his lack of imagination and sentimental choice of subjects. His commercial attitude made him a popular painter, but separated him from the earnest aims and ideals of the pre-Raphaelites.

Ford Madox Brown (1821–1893) was in sympathy with them and to some extent anticipated their ideas. His defect—a not uncommon result of pre-Raphaelitism—was an over-conscientious desire for improvement of his painting, which led him into a bad habit of re-touching; his great qualities were his understanding of fine linear design and his sense of colour. Notable pictures are "Work" (Manchester City Art Gal.), "Last of England"

(Birmingham), and his masterpiece, "Christ Washing Peter's Feet" (National Gallery)

Sir Edward Burne-Jones (1833–1898) and William Morris (1834–1896), though both influenced by Rossetti, worked with entirely different aims The latter actually had a very small pictorial output, but is famous for his influence on the art of his day, and even more so for his championship of the social aims of the people; for that insistence on the necessity of beautifying things in common use which revolutionized many homes throughout the land, by leading to the foundation of the firm of Morris & Co This celebrated firm undertook the beautifying of everything from wall papers and furniture to table ware and tapestry. Unfortunately, influenced by Ruskin, Morris refused to recognize the possibility of beauty in machine-made goods and thus, instead of being a forward movement, much of his work was retrograde, while designs for the machine-made goods of his day were divorced from aesthetic authority

The earliest work of Burne-Jones was in water colour In these pictures and in his subsequent oil paintings was a special appeal to the literary public on account of their "poetical and conventional art." Influenced by the lovely linear designs of Botticelli, Burne-Jones possessed great imagination and a highly decorative sense of pattern He devoted much time to designs for stained glass windows, to be carried out by his friend William Morris, and prepared many illustrations for the Kelmscott Press, notably for the Morris edition of Chaucer

In spite of the subsequent confusion of its motives, pre-Raphaelitism undoubtedly acted as a spur to British art, even after Ruskin's championship of it—and lamentations over its backsliders—had ceased to reverberate It urged sincerity in art-thought and honesty of craftsmanship, and although the "precious" technique associated with it died out, much of the courageous independence shown by British artists towards the end of the century was due to the new spirit it inculcated English sculpture also, which up to the middle of the century knew only that solitary genius Alfred Stevens—though hardly equalling the French achievement—asserted itself as never before. The work of Sir Alfred Gilbert (b 1854), sculptor of Eros in Piccadilly Circus, represents the dignified taste of the period; that of Alfred Drury shows decorative skill. He is specially noted for his groups of sculpture at Leeds and for his many war memorials.

LESSON 20

Rise of the Romantics and Impressionists

(See plates 12-14)

To assume that the French mind is inherently classical in art is a hasty generalization. Tradition is certainly upheld and culture widely appreciated, but a review of the great pictorial productions proves that the French genius is capable of the most amazing departures from academic standards and of the highest original conceptions. After the turmoil of the French Revolution there was certainly a harking back to the antique, but this developed from mere imitation into a creative movement, a feeling for order out of chaos, of which Jacques Louis David (1748–1825) was the leader.

State artist under the Republic, Master of the Ceremonies for the Republican festivals, David was appointed Court painter when Napoleon arose and the Empire style in art and decoration appeared. Greco-Roman forms were the fashion. Laurel wreaths, acanthus leaves, columns, eagles, the toga, classical draperies and sandals were affected in sculpture and as details in settings and costumes both in contemporary portraits and in historical paintings. The Arc de Triomphe is the most famous French architectural work of this period, which lasted until 1830; Empire style was reflected in England by the classical decoration and architecture of the Regency period.

Well-known pictures by David are his early painting of "Marat Assassinated," his portrait of Madame Récamier, and, among his historical paintings, "The Rape of the Sabines." His work is distinguished by a sculpturesque quality of clear-cut accuracy of form and occasionally marred by resultant hardness of texture and by some monotony of colour. His most famous pupil was Jean Auguste Dominique Ingres (1780–1867), who also shows fine restraint of style and superb draughtsmanship, carrying on the nationalized classical tradition in all his work. In the National Gallery, London, is an excellent example of Ingres' portraiture: "M. de Norvins"; and also two small historical paintings. "La Grande Odalisque" in the Louvre is, perhaps, his most celebrated picture.

Completely opposed to Ingres was Eugene Delacroix (1798–1863), the leader of the Romantic movement who has been called the Byron of French art He was considered a revolutionary, but his mastery of colour was officially recognized and he was employed to decorate a ceiling in the Louvre and the interior of the Chamber of Deputies A famous picture is his "Liberty Leading the People," now in the Louvre In his landscapes he was influenced by the art of John Constable A number of lithographs for the book trade evinced the imagination and vitality of his talent His art today is quite out of fashion, while that of Ingres, duly admired as being based on simplicity of form and unblurred line, goes on, its directing structural influence pointed to the development of Cubism

With Delacroix, however, began that revolt against official art which set a fashion of being proud when work was refused by the Academy and of painting to please oneself Théodore Rousseau (1812–67), another Independent, known as "Le Grand Refusé," was at first entirely outside the pale of recognized art He, after settling in Barbizon, became the founder of that school of landscape painters also made famous by the work of his associates, Diaz, Daubigny, Millet and Corot We have seen in Lesson 18 (Vol 3, p 81) that the painting of John Constable profoundly influenced the Romantic landscapists of the Barbizon school It can also be claimed that he and Turner showed the way to the French Impressionists, but if French art owed a debt to England in the first half of the 18th century, France repaid it in the second half, and since has set the pace for the world

Barbizon School. The classical painters had been in bondage to the past in choice and treatment of subject The Romantics of the Barbizon school and elsewhere established the artist's right to take subjects from every phase of life and paint them according to personal vision, a right afterwards consolidated by both Impressionists and Post-Impressionists Of the "Independents" in Barbizon, J F Millet (1814–75) stands out by reason of the simple directness of his vision The son of a peasant, who had spent his boyhood in his father's fields, he had one motive in all his works "Man goeth forth to his labour until the evening" Visualizing rustic France with complete understanding and sympathetic power, he is recognized as one of its greatest painters Well-known pictures by him are "The Gleaners," "The Angelus," "The Man with the Hoe,"

and that composition in lovely light, "Le Printemps," a landscape at Barbizon of a field traversed by a path between fruit trees, the fresh green of which stands out against the dark sky arched by a brilliant rainbow.

The work of Jean B. C. Corot (1796–1875), one of the finest landscapists who ever lived, differed from that of the other Barbizon painters in that it united Classicism with Romanticism. Perfection of technique characterizes his composition and painting; he combined breadth with exquisite delicacy. He is well represented in British galleries. His reputation suffered somewhat owing to the vast number of spurious works attributed to him, which were produced by copyists to meet the great demand for his pictures. Among his masterpieces are "Tivoli from the gardens of the Villa d'Este," "Danse des Nymphes," and many of his numerous paintings of misty rivers and lakes, serene moonlight and trees.

An interesting independent painter with a strong dramatic sense was Honoré Daumier (1808–79), who began as a caricaturist and poster artist. Later he excelled as a sculptor, modelling his "masques" of politicians from memory. As a painter, though one of the pioneers of realism, he was also able to visualize in imagination his Don Quixote series. The Parisian scenes which he illustrated in his pictures were mostly of the seamy side of life. If Delacroix may be called the Byron, Daumier was the Charles Dickens of French art. Another realist, Gustave Courbet (1819–77), portrait painter and landscapist, was one of the artists from whom Edouard Manet (1832–83) learned, though he owed more to Titian, Hals, Rembrandt and Velazquez.

French Impressionists. With Manet we arrive at the French Impressionists. The word came into use in the eighteen-seventies, when an equally famous leader of the group, Claude Monet (1840–1926), named one of his pictures "Sunrise—an Impression." The other great French painters connected with this movement, the most important in the art of the time, were Edgar Degas (1834–1917), Alfred Sisley (1840–99), Pierre Auguste Renoir (1841–1919), Camille Pissarro (1850–1903), and Manet's pupil, Berthe Morisot (1840–95).

Within a few years of the pre-Raphaelite agitation in England, Manet painted his "Olympia," a work in which the seemingly deliberate ugliness of the subject was a direct challenge to all previous ideas of beauty in art. It may be regarded as Manet's

declaration of independence with which to startle Paris and shock the critics and the picture certainly made a great sensation Many of his other paintings are, however delightfully amusing in their sympathetic portrayal of character as for example, " Chez le Père Lathuile,' or his earlier picture Le Bon Bock " His work has penetrative quality , he revealed by his fine perception of colour and form In his earlier pictures his designs are more compact and structures are more definitely explained but in his later work colour in its relation to light is his supreme interest " La Servante de Bocks " (Millbank) a scene in a Paris cabaret, is a good example of his later style In all his work his aim was to state ordinary things and people with pictorial truth

Light studied scientifically was the keynote of Impressionism. Claude Monet, after studying Turner's work in England, began to paint with broken strokes of the brush, laid down in touches of pure primary colour The effect produced is both brilliant and luminous, as may be seen in his " Vetheuil Sunshine and Snow," at Millbank There is no structural solidity in some of Monet's pictures, he deliberately sacrifices it to atmospheric effects. In Pointillism, of which Georges Seurat (1859–91) was the most famous exponent, this absolute painting of daylight was carried a step farther by painting in spots (points) of primary colour. It was in Turner's later work that the scientific juxtaposition of the three primary colours, red, blue and yellow throughout a picture was first introduced though Gainsborough, Watteau and Rubens had made occasional and partial use of the method in landscape to obtain sunny effects

Edgar Degas was another Impressionist of genius who, with Manet and Monet, has influenced English art In addition to his fine rendering of light and atmosphere, he possessed a mastery of anatomical construction, and a superb vitality of movement characterizing his pictures of the circus, the ballet and the racecourse Alfred Sisley's landscapes, drawn directly with the brush, possess a spontaneous charm Renoir's sensitive and brilliant painting is seen to perfection in his many portraits and genre pictures . one of his best known paintings is " La Loge," in which a woman, in a black and white evening dress, is seated in a box at the theatre with a man in evening dress. Both figures are superbly realized Renoir painted with long strokes of the brush, using a preponderance of red and green, which gave

great brilliancy to his work. Two fine works are "Les Parapluies" and "La Première Sortie," both in the Millbank Gallery Toulouse-Lautrec was strongly influenced by demi-mondaine types. His "Absinthe Drinkers" is especially outstanding. The art of the poster dates from the Impressionists. In France the finest poster designers were Toulouse-Lautrec and Chéret, while in England Dudley Hardy and the Beggarstaff Brothers (James Pryde and William Nicholson) were famous pioneers.

Puvis de Chavannes (1824–98), though a "refusé" from the salon, is not an Impressionist. His mural paintings were an inspiration to the succeeding generations, and he greatly influenced decorative art in England.

Whistler. The Impressionist movement spread through Europe. In England one of the greatest exponents was James A. McNeill Whistler (1834–1903), an American by birth who had studied in Paris. With his contemporary, Edouard Manet, he desired to break away from the academic in art. His "White Girl" (Nat. Gal.) roused as great excitement and protest in the "Salon des Refusés" (inaugurated by Napoleon III) of 1863 as Manet's "Déjeuner sur l'herbe." Whistler's arrival in England was a landmark in the history of our art. His interest in Japanese art and its influence on his work—an influence exercised on most of the French Impressionists, including Manet and Degas—helped to turn attention away from the classical tradition and to present an entirely novel aspect of painting, in which freedom of design—with an understanding that empty spaces could add value to its beauty—and new effects of perspective played an important part. Whistler also helped to form the close alliance with French art which was so marked in England at the end of the 19th and turn of the 20th century. Among his most famous paintings are the portrait of his mother, painted in 1872 and subsequently bought for the Louvre, the portrait of Thomas Carlyle (Glasgow), the "Princesse du Pays de la Porcelaine," the lovely design of "Old Battersea Bridge" (Millbank), known also as "Nocturne—Blue and Gold." His etchings and lithographs are unique in their delicate craftsmanship. His perfection of taste in composition and art of selection have seldom been equalled by English painters, although his "Nocturnes" were adversely criticized by Ruskin in "Fors Clavigera."

The great revival in English landscape painting during the last forty years owes much to the French Impressionists. Only

a few names can be mentioned here. Wilson Steer, Henry Tonks, Lucien Pissarro, Charles Holmes, and George Clausen are all Impressionists—using the word in its highest sense—whose greatest gifts are for painting atmosphere and lovely effects of sunlight. Steer is also a sympathetic portraitist; and Sir Charles Holmes is one of the first painters to discover beauty and pictorial pattern in factory chimneys.

Sargent and Sickert. In portraiture the Impressionists in England include J. S. Sargent (1856–1925)—who, like Whistler, was of American parentage and studied in Paris—and Whistler's pupil, Walter Sickert (b. 1860). Sargent was a prolific and often fine painter, though unequal as a colourist; like his master, Carolus Duran, he was inspired by Velazquez; his style is characterized by loose brushwork and greatly influenced contemporary artists. Walter Sickert, in addition to his portraits, is a great painter of landscape and *genre*—indoor and outdoor scenes of cosmopolitan life. His highest gift is the power of expressing not only physical but emotional atmosphere. He often paints a cool tint—such as a mauve shadow—over a warm colour—such as an orange ground—representing sunlight. A typical work is the "Café des Tribunaux, Dieppe," at Millbank.

It is the fashion now to say that the Impressionists are materialists, but this is hardly a just criticism, as the works of the painters mentioned show the true spirit of poetry. Though the art of photography has advanced and a snapshot can illustrate a realistic episode, no camera can give us the exquisite gradations and tones of colour in their relation to light as they may be seen in the work of Manet, Monet, Renoir or Degas.

LESSON 21

The Reaction of Post-Impressionism

(See plates 15 and 16)

BECAUSE human nature is suspicious of the unfamiliar, new forms of art seem ugly, sometimes even comical, on their first appearance; gradually, if the idea has been truthfully stated—and the truth may be abstract or concrete—beauty is revealed to the beholder, as understanding increases and prejudice lessens. The perfection of naturalistic and luminous painting had been reached by the masters of the

Romantic and Impressionist movements, nothing more along their lines seemed possible Manet and Degas had combined realism of atmosphere with superb draughtsmanship; Seurat had taken Monet's brilliant colour schemes scientifically farther with Pointillism and, in addition, achieved, in such pictures as "The Woman Powdering Herself" (Courtauld Collection) and "The Bathing Party" (Millbank), a monumental solidity which was a step towards one of the demands of the rising school of painters—the demand for architectural form, lacking in the work of the Impressionists (*see* Lesson 20, page 64).

Mr. Roger Fry named these new painters at the end of the 19th century Post-Impressionists. They declared that their predecessors had sacrificed structure for atmospheric effect—theories of light had become too complex. Though the Impressionists had shown people aspects of Nature which they would otherwise have missed, naturalism was condemned: art is not Nature, they said; "it is a pattern or rhythm of design that we impose on Nature." Mere unselective copying was quite despised: it was being challenged by the camera. They argued that a photographic study could be more realistic than any painting.

Cézanne. All reactions in art are exaggerated; if they were not they could not gain sufficient impetus to attract attention or become a movement. Movements arise out of exasperation against narrow mental conceptions, and attempts at standardization in art. The desire to avoid the faults of the previously accepted school restores balance by a swing-over. But this one-sidedness, however useful as a corrective, does not help progress; only strongly creative leadership is able to do that. Paul Cézanne (1839-1906), striving towards perfection with unceasing experiments, hit upon the method which revolutionized modern painting.

Though Paul Gauguin (1848-1903) and Vincent Van Gogh (1853-1890) were also originally in this revolutionary movement—which only reached the London public at the Grafton Galleries' Post-Impressionist exhibition in 1910, when the chief painters represented were dead—they were independents. It was Cézanne who inspired numerous followers; it was Cézanne whose very failures were stepping stones for other artists. In his many uncompleted efforts they could see what he had been striving for technically; what they could not emulate was his possession of spontaneous emotion—he was always going beyond impressions

in his search for some poetic, spiritual quality Turning to painting rather late in life, though a genius, he was never able to acquire facility or a good figure memory, also he disliked working from models. He set himself a difficult ideal to combine the best effects of impressionism with the structural qualities of Nicolas Poussin—light and colour with architectural drawing and form Cézanne has been declared a bad draughtsman. His aim was not to outline, but to suggest modelling. Everything in his estimation could be resolved into geometrical forms—all shapes simplified into cylinders, cones and spheres; his very brush strokes were mostly angular He was thus the man behind Cubism, which, however, did not develop as an art movement till 1908. He made still-life pictures like patterns, just for the pleasure a pattern can give He considered that a beautiful invention was better than the meticulous copying of grouped objects after the fashion of a Dutch painter

Though Cézanne was often unable to carry out his pictorial conceptions his successes with The Card Players" (Louvre), "The Young Philosopher," and his masterpiece "La Montagne Sainte Victoire" (Courtauld Collection), with its solidity of mountain form, have a fine massive simplicity and sometimes a colour value as sensitive as Turner's own Cézanne has been credited with the discovery of "essential form"

Beginning with Cézanne, the Neo impressionists—with only a few exceptions—demanded the "illusion of solidity" In common with the English pre-Raphaelites their aims were structural, not merely visual like those of the Impressionists The pre-Raphaelites, however, with all the mass of structural detail which they introduced into their pictures, could never attain the same "roundness" seen in the work of Cézanne with his simplification of forms In Turner's painting the structural and visual aims were nearly reconciled, Mr Roger Fry has said that each reform in the history of painting has been an attempt to balance these two aims

Gauguin. Paul Gauguin's links with Cézanne were repudiation of naturalism and a certain defiance of perspective Partly Peruvian on his mother's side, he developed on individual, exotic lines as a supremely decorative artist Superb in colour and design, his art has chiefly influenced designers for decorative industries. His aims are apart from the modern in serious painting, and for this reason he is not so important as Cézanne.

The consistent illusion of solidity does not appear to trouble him. Using a heavy outline frequently to unify his design, Gauguin's figures are either quite flat or in relief—sometimes in the same picture. While negligent of scientific lighting effects, he produced deeply psychological atmosphere in many of his works painted in Tahiti, where he went in 1891, specializing thenceforth in poetic and faithful renderings of the rich colour and spirit of the South Sea Islands. Notable among his pictures are "Contes Barbares," a barbaric idyll of two women and a man amongst lovely and strange flower forms; "The Spirit Watchers," "Nevermore" and "Te Rerioa," studies of native women charged with mysterious or tragic feeling; also his portrait of Van Gogh.

Van Gogh. This artist, a Dutchman, began to paint in Paris in 1886. His work was chiefly influenced at the outset by Pissarro, Renoir, Cézanne and Seurat. In common with Renoir he used much green and red, with resultant masses of splendid colour in his vigorous designs. His painting is somewhat hard, applied with heavy strokes, sacrificing, after the fashion of the Post-Impressionists, delicate qualities of texture to structure and form. He concerned himself, as did Cézanne, chiefly with pattern. This did not impair his power of characterization in his portraits, while it gave a strange clear-cut beauty to his flower pieces and landscapes.

Matisse. The most distinguished associate of the three Post-Impressionists already named was Henri Matisse, born in 1869, who carried the search for abstract pattern still farther—so far, indeed, that some of his subjects are deprived of resemblance to Nature. He painted landscape, figure, interiors and flower pieces. Beginning under the influence of Cézanne, later Matisse led the Fauves, at one time termed "the incoherents."

Fauvism was taken up in other European countries and found particular acceptance in Germany. The group headed by Matisse returned to direct simplicity of expression. He, like a Primitive, worked freely with colour and line; like the early Italians, he submitted to the "discipline of rhythm" but not to the discipline of Nature. Copyists of Matisse failed because he could make no rules for their guidance. He paints each picture with the treatment he feels that it requires, inventing new qualities in the sensitive relations of colour and in line. Breaking away from Cubism (see Lesson 22), he painted flat, ignoring alike shadow, modelling and perspective.

LESSON 22

Developments in Modern Painting

(See plates 17 and 18)

AFTER the Post-Impressionists and the Fauves in 1908 arose the Cubists, with Pablo Picasso (b. 1881) as their leader. Cubism, as the name implies, is mathematical in form; in its purest style it deals solely with abstract patterns, and its aim has been defined by Roger Fry as an "abstract language of form—a visual music." Carrying Cézanne's geometrical simplification farther, the Cubists declared that the abstract primitive form is the cube; circles are merely edge-worn cubes; flat instead of curved surfaces are, therefore, emphasized in their compositions. Six cubes can form a primitive human figure—four for the limbs and two for the head and trunk Cubes lend themselves readily to making fine geometrical patterns. Anyone who looks at what is known today as "modern" design in rugs, tapestry, wallpaper, dress fabrics or pottery is really seeing patterns which owe their origin to the art experiments of the Cubists and Fauves; receiving their form from the first—cubes being split up into facets at will—and line and colour from the second group, with a few subsequent developments and profuse adaptation.

The excellent side of the Cubist training is the ability it gives to resolve things to their simplest forms and to grasp their essential shapes; to hate alike sentimentality and vague treatments; to regard a weak, blurred outline as a crime and to prefer even a distortion. Cubist pictures are hard and definite, their atmosphere and texture sacrificed to their technique, but the method of splitting the object up into facets of flat planes means that its structure has been understood and the result can never be pretty-pretty or dull. The Cubist—or any structural painter—values light as a means of explaining form; faces of planes are differentiated to the eye by the tones resultant from the angle at which the surfaces are to the light; painting these tones lighter or darker gives the object its "solid" shape.

Picasso. Pablo Picasso, though born at Malaga, is counted among leading French painters; he settled in Paris in 1903, and came into the reactionary group of the Post-Impressionists.

His earliest paintings are both poetic and realistic, notable achievements. Like Watteau, Daumier, and Degas before him, he often chose his subjects from the picturesque behind-the-scenes of the entertainment world—pierrots, the harlequinade, circus characters, the ballet. After a brief incursion into "l'Art Nègre," which was intriguing Paris in the years before the war, Picasso, drawing inspiration from El Greco and Cézanne, formulated Cubism. In this movement Juan Gris, a Spaniard born at Madrid (1888–1927), was soon associated. His portrait of Picasso, painted in 1912, is a clear example of early Cubist technique, with its effect of a first stage in a wood-carving. About some of Picasso's work at this time is an extraordinary feeling of disintegration, expressive of the analytical thought and general disruptive tendencies of the decade preceding the Great War. He sometimes put his portraits together in fragments from different points of view (after the manner of ancient Egyptian reliefs) ; they may show the eye full face in a profile, the shoulders square to the spectator and the legs again viewed sideways. Such experiments on his part were, however, educative and directed towards the clearing away of his old concepts and creating afresh, and not merely imitative

Picasso about 1915, with the French painter Georges Braque (b. 1881), began studies in abstract pattern, not to imitate but to create form ; perspective and realism quite vanished from his pictures. Both painters used objects such as violins, jars, pipes and tools, merely for their intrinsically decorative shapes, to form compositions ; from these things they created not ordinary still-life pictures, but new patterns. It was during this period of his experiments that Picasso so greatly influenced modern design, Cubism has practically changed the forms of nearly everything made within the last twenty years. Of late his painting, still in the experimental stage perhaps, has become even more difficult to understand, but he is accepted as a master of organized form and constructive design, and both architecture and sculpture have been influenced by him, as well as industrial design, throughout the civilized world. He has transferred ordinary reality to poetic ideality.

Later developments in France include "Beyond Cubism," or Purism ; Dadaism, which appeared in 1920, machinery forming the basis of its designs ; the Sur-realists ; and the New Independents, reacting against Cubism. Le Corbusier, the famous

French architect and leader of Purism, defines style as "unity of principle animating all the work of an epoch, the result of a state of mind which has its own special character." Our own epoch is determining day by day its own style. Out of all these movements mingled, we have the modern style.

Futurism and Vorticism. Of Futurism, which started in Italy in 1910, under the leadership of the Italian writer Marinetti, and of Vorticism, there is only space for briefest mention here. These movements originated in the years before the War in a wave of dynamic violence in art, with its increasing interest in machinery and its wild desire for emancipation from the past. In Futurism arbitrary symbols—"force lines and rhythms" together with quasi-geometric patterns—are substituted for realistic representation; a work of art is a purely subjective expression in an absolute, personal "language." Attempts to paint the passage of time—by drawing, for instance, ten arms to represent a single arm in motion—are a phase of Futurism which is a synthesis of the movements of living creatures, or of objects in activity. Vorticism, a variation of Cubism and Futurism, found its appropriate subjects in the mechanism of modern weapons, and in vast armies of robot-like creatures at drill or on the march. Wyndham Lewis is the chief exponent of Vorticism in England, with his compositions of planes and wedges, the cast-iron countenances of his inhuman figures, the symbolism of mass production and general mechanism of the machine-ruled modern world.

In England, Claude Flight is the most intelligible and ingenious follower of Marinetti's Futurism; he has latterly developed a fine technique in lino-cuts and is the leader of a group in this interesting branch of graphic art, which differs from that of the woodcut, not only in the use of a different material and in greater resultant softness in the print, but also in the method of printing. The transference of colour from the lino-block to the paper is effected by rubbing on the back of it and not by means of the printing press. This gives the lino-cut an effect somewhat similar to that of the Japanese colour prints.

The Nash Brothers. The art of the woodcut has also returned to favour. Leading figures in its revival are the brothers Paul and John Nash, born respectively in 1889 and 1893. The work of both these artists is of extraordinary interest. Examples of their war pictures show the strong influence of Cubism, in their

striking patterns and three-dimensional solid compositions. Even in later work their methods are powerfully structural, the very antithesis in landscape of those of the Impressionists. John Nash, however, shows a tendency to revert to naturalism; without losing his fine sense of pattern he is dropping certain mannerisms and increasing his breadth of handling masses and sense of atmosphere. Paul Nash has a wide range—from such pictures as his war landscape, "Menin Road," with its terrifying effect of space, to his fine seascapes, sympathetic water colours, dramatic woodcuts and posters

Augustus John. Though born in 1878, Augustus John is essentially a modern painter while independent of prevailing "isms." His painting is vigorous; his skill in composition, especially in his large group pictures, is magnificent, as may be seen from the study of his decorative cartoon "Galway" at Millbank. His portraits are dramatic and spontaneous—the latter quality ranks John in the opinion of some critics among the Impressionists—remarkable alike for fine draughtsmanship and rich colour. Notable examples are his "Madame Suggia," "The Smiling Woman" and "The Yellow Jacket," at Millbank; in Manchester are "Meirikli" (Platt Hall), the portrait of a dark-haired woman of interesting personality, comparable in its fine design and painting with a Venetian master's work, and the "Boy" (City Art Gallery), with its simplified yet accurate treatment and fine brushwork.

Nevinson and other War Painters. The painting of such men as the Nash brothers, C. W. R. Nevinson, Stanley Spencer and Henry Lamb in their tragic war pictures combines vivid reality with the hard definite style, which is, in great part, their individual development of Cubism. Their war pictures should be studied in the Imperial War Museum, together with others by artists for bare mention of whom there is no space here. A powerful war picture by Nevinson is "La Mitrailleuse" at Millbank. Here the grim reality and cruelty of war are terribly expressed by the simplification of the forms into straight-edged planes of light and shade.

As Mr Charles Johnson, in "English Painting," has pointed out, Henry Lamb's great war pictures, "Irish Troops among the Judean Hills" (Imp. W. M.) and "The Advanced Dressing-Station on the Struma" (Manchester City Art Gallery), exhibit pre-Raphaelite minuteness of detail. In his later work this

painter has shown deeply sympathetic insight into character in portraiture. An early work, " Phantasy " (Millbank), is a fine example of his aim at constructing solid shapes with firm, hard contours.

Stanley Spencer is a very accomplished, original and deeply sincere painter. Apart from his war pictures, which include a series of mural paintings on the walls of an oratory at Highclere, his most successful works—or, at least, his most popularly appreciated—are his landscapes. His mystical paintings, " Christ bearing the Cross " and his large " Resurrection " (both at Millbank), show extraordinary distortions of bodily types and inhumanity of faces. It appears impossible for the painter to combine his mystical ecstasy with the convincing realism which marks such beautiful pattern-compositions as " Fighting Swans " and " Swan Upping at Cookham."

The broad result of all these intellectual—mathematical and philosophical—art movements has been to promote in English painting structural composition, sincerity, and an echo of that affection for painstaking detail which marked the work of the great pre-Raphaelite Holman Hunt. This Lesson completes the brief summary, beginning in Lesson 13, of European painting from the Primitives to the present day. Of necessity, in the limited space available, many interesting painters have been omitted ; various tendencies in art have not been dealt with. The student is recommended to visit all notable picture galleries and loan collections within reach, and also to attend any lectures given by official lecturers, or other authorities on painting, when opportunity arises.

LESSON 23

Sculpture Without Prejudice

(See plates 19 and 20)

AFTER the apogee to which the genius of Donatello and, later, of Michelangelo had raised the art of sculpture (see Lesson 14, Volume 3, page 64), it languished throughout Europe for the best part of two centuries, only galvanized from torpidity by flamboyant design and the " movement " which characterizes decorative art of the rococo period. This decadence may be broadly described as the aftermath

of the revival of interest in everything Greek by scholars and pedants, pursuers of the dead letter of the Renaissance as opposed to its living spirit of scientific inquiry and adventure. It was largely due to the proliferation by the antique dealers—who arose in the Renaissance era and flourished thereafter on the sale of spurious and restored Graeco-Roman statues, to propaganda of dealers and collectors, and to the popular taste created thereby for everything pseudo-classical, which came to be recognized as the standard of beauty irrespective of the sculptural merit of the particular piece. It was thus much easier to make a living as a restorer, as a copyist of the antique, or as a conventional sculptor of the ideal, than as an original artist.

In his provocative and interesting book "The Meaning of Modern Sculpture" (Faber & Faber), R. H. Wilenski analyses the unwholesome ingredients of what he calls "prejudice-pie"; of these the two most injurious to any mental digestion of creative modern ideas on sculpture are: (a) "the Greek prejudice," which imposes a belief that first and last, absolute perfection in sculpture was reached by the Greeks, thus leaving every sculptor since at a dead end, and ignoring the previous glories of ancient Egyptian, Assyrian and Persian carvings; (b) the "Renaissance prejudice," which assumes that the sculptors of this age imitated the Greeks to perfection, capturing the ancient Hellenic spirit. The third and least important ingredient of the pie is the "Romantic prejudice." This prejudice consists of extending the finality-form of good sculpture to admit as worthy companions of the Greek the works of Rodin and other works like them. "The average person's concept of sculpture is thus a finality form operating as a prejudice against modern sculpture, which is placed outside the prejudice pie both in point of time and point of value."

Donatello and Michelangelo. Mr. Wilenski observes that Donatello, the most typical of 15th century figures, far from copying the antique, forestalled the Romantics of the 19th century; that his work has been of cardinal service to Epstein as a modeller for bronze; that Donatello's art was not Greek, was not even specifically Italian, but international and intensely Gothic in character. "It is not till we get to Michelangelo's work in the 16th century that we encounter sculpture that is no longer Gothic, and Michelangelo's attitude . . . was more like that of the original sculptors of our day." The last statement refers

to the Italian master's preference for *carving* as opposed t *modelling in clay* a preference shared by many modern sculptors

Michelangelo himself carved his own statues, directly int marble, generally without the aid of a preliminary model, excep a small sketch in wax or clay He regarded carving as essentiall sculpture and modelling as an art similar to painting Obviously plastic clay is the most suitable medium for the subtleties c naturalistic sculpture or portraiture embodying the Romanti doctrines "that art is nature seen or imagined through th artist's temperament, and that sculptural beauty is emotional expressive character" (Wilenski, *ibid*) Direct carving demands greater accuracy, labour and clarity of concept Michelangelo considered that 'the finest artist has no concept which the marble alone does not contain within itself" This idea that essential sculpture is "collaboration between the sculptor and the block of resistant substance beneath his hand" is also in the creed of the modern artist who appreciates his material

Precursors of Michelangelo, the medieval architectural sculptors, were also concerned with helping stones to symbolize life, they were not concerned as are modellers of the Romantic school, with "converting living figures into dead material"

The worship of the 'antique' was just as annoying to the independent and scientific minds of the Renaissance creative sculptors as prejudice-pie is to those of our own day Donatello's and Michelangelo's work was regarded by contemporary collectors as utterly inferior to the ideal, restored statues finished with more or less appeal of sensual beauty according to the customer's requirement The output of Greco-Roman sculpture was vast, practically every Roman house, every public building and place in the Empire, east and west, was decorated with statuary, either looted by the Romans from Greece in the 2nd century B C, or produced by their own sculptors Almost equally vast was the scale of statue breaking by the Goths and Vandals in their raids over Latin-Hellenic territory and, in the 8th century, of the iconoclasts like Leo the Isaurian who destroyed countless statues in Constantinople for religious reasons as images, while others, remaining when the iconoclast fury was spent, were refashioned from the original Greek into Christian images

Concoctions of Antique Statues. By the 10th century a whole antique statue would be a rare find indeed—the bulk were either melted down if of bronze, or, if of stone, were in fragments buried

in the ground. With the revival of Greek culture during the Renaissance the unemployment question of the day was met by enrolling gangs of diggers to unearth these fragments, and by the tremendous work in restoration and concoction started forthwith by the lesser sculptors and assistant craftsmen. The dealers in antiques supplied the Vatican, the courts of Europe, noble collectors and museums with ideal restored or faked antiques from thenceforth.

World-renowned pieces as we see them to-day—the "Venus de Milo" and the "Victory of Samothrace," to mention only two in the Louvre—are concoctions of fragments put together by restorers. The torso alone of the "Victory" consists of 118 pieces stuck together after arrival in Paris in 1863, the fragments having been sold to a Frenchman in the island of Samothrace. How can all these fragmentary compositions—even if the result is sometimes beautiful—be considered as authentic antique sculpture? Mr. Wilenski, with reference to the "Victory," says, "If this concoction had been concocted a hundred years earlier, it is, I submit, only reasonable to suppose that we should know it in quite other and more Greco-Roman shape." In Lesson 5, volume 1, page 39, a more conservative view is expressed of Hellenistic art. To-day the sculptor is apt to react too violently against it owing to the abuse of the Greek tradition; mere imitation must always be stale and unprofitable

Renaissance Sculpture. The Middle Ages were free from the Greek prejudice, and much fine and vigorous sculpture was directly carved in stone on Gothic cathedrals, etc. (*see* Lesson 11, volume 2, page 39). After the Renaissance the work of that elegant craftsman Lorenzo Bernini (1508–1680) affords a striking example of the deplorable decadence which set in. Successful in his day as sculptor, painter and architect (in architecture his most notable achievement is the colonnade of St. Peter's, Rome), on contemporary sculpture he exercised a baleful influence, with his pseudo-classicalism, his extravagance of design and his emotional theatricality. Some of his work, after the type of "Apollo pursuing Daphne," possesses a pretty grace which, when dwindled to the proportions of chimney-piece ornaments, could serve as an inspiration for the designers of mythological figure groups in the china factories. His portrait busts of royal and noble personages show his delight in the long hair or huge wigs and in the intricate patterns of the lace collars in vogue at the time.

adding to the swirling effect of movement, he swathes the shoulders with voluminous drapery.

The sculptors of the Renaissance were so scientifically curious that in their endeavour to achieve naturalistic portraits they used death-masks and casts from life as studies. Bernini could turn out an admired bust in his most expensive style from two paintings—without seeing the original and without imaginative vision—all blemishes omitted.

Houdon. Jean Antoine Houdon (1741-1828), the French sculptor, working in the latter half of the 18th and early 19th centuries, forestalled Rodin in his Romantic interest in emotional character, realistic detail and expression. He certainly put in the blemishes. His portrait bust of Gluck, the composer, shows on the animated face traces of small pox. Away from the conventional allegorical figure is Houdon's "Negress," designed during the French revolution for a foundation to commemorate the abolition of slavery, proclaimed by the National Convention, Feb. 4, 1794. A plaster cast of the head is temporarily in the Louvre. Ideal groups were sculptured by him, but it is as a portrait-sculptor that he is famous: busts and statues include J. J. Rousseau, Voltaire, Mirabeau, Lafayette, Franklin, Washington (he visited America to execute this statue) and Napoleon. A marble bust of the Emperor, exhibited in the Salon of 1808, is now in the Musée at Versailles.

Contemporary with Houdon were the Italian sculptor Antonio Canova (1757-1822), who produced a vast amount of highly finished work on academic pseudo-classical lines, and John Flaxman (1755-1826) in England. Flaxman, also, was academic in style, and his chief claim to admiration lies in his designs for engravings to illustrate Dante's "Divine Comedy," and in his decorative line "Illustrations to Homer," rather than in his monumental or ideal sculptures.

Alfred Stevens. A follower of Canova's artificial tradition of smooth grace, and equally hidebound in "Greek" convention as understood in his day, was Bertel Thorwaldsen (1770-1844), a Danish sculptor who worked in Rome for forty years and executed many allegorical and "pagan" statues. A portrait bust of Byron by him is at Cambridge, but the principal collection of his works is at Copenhagen. His pupil assistant, Alfred Stevens (1817-1875) possessed, in common with other great artists—Poussin, David, Ingres and Turner, for instance—the faculty of

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abstracting knowledge for his own purposes from his profound study of the work of Michelangelo and other masters. Stevens returned to England in 1842, the most thoroughly educated artist of the 19th century. His was the inherently classical temperament—using the word classical in its meaning of austerely grand and dignified, and not Greco-Roman (*see* Lesson 19, page 60). A representative collection of his work is at Millbank, and plaster models for the Wellington monument, St Paul's, and of the fireplace for Dorchester House are at Victoria and Albert Museum.

Rodin. Seeking and experiment are the keynotes of original artists: sculptors have had their part in the movements briefly described in the previous Lessons in this Course. The greatest sculptor of the Romantic movement in the 19th century was Auguste Rodin (1840–1917), who began his artistic training in the studio of Antoine Barye (1795–1875), a French sculptor noted for his bronze animal groups and statues, such as his famous lions at the Louvre. Like the Impressionist painter Manet, Rodin's first recognition by the art critics was effected by shock. In 1864 he exhibited the statue of a "man with a broken nose." By 1877 he had "arrived." His "Age of Bronze," in the Salon, was acquired by the State and placed in the Luxembourg Gardens. A bronze replica of his "Burghers of Calais"—which outraged all the conventions of his day—may be seen in the Victoria Tower Gardens, London, while his magnificent gift of representative sculptures to the British nation during the Great War is at the Victoria and Albert Museum. His famous "Thinker," his "Eve," which excited quite as much protest and initial disgust as any statue of Epstein's, and his greatest work, "The Gate of Hell," illustrating Dante's "Inferno," containing 186 figures—which took up almost all his lifetime from 1880, and was left unfinished—all these show his dramatic expression and power of conveying emotion by gesture and pose. His habit of leaving a figure emerging from an unfinished block is intentional and characteristic of his Romantic tendency, not only to force contrasts but also to focus the spectator's attention on the particular point of interest which the sculptor wishes to stress by completing that portion and leaving all else in the rough.

Rodin never carved; clay modelling was the only possible medium for his work. The varied surfaces when cast in bronze aid the impressions he desires to create. Marble versions of his statues were produced by independent marble workers.

LESSON 24

Universal Forms in Sculpture

(See plates 21 and 22)

To label the art of our period the end of the Romantic-Impressionist movement and return to Classicism (using the last word in its austere meaning) is partial truth Form is certainly set above feeling structure before impression, there is appeal to the intelligence rather than to sentiment, reliance on mathematical axiom and fundamental shapes rather than on association of ideas, but it is here that we branch away from the Classic revivals of the past The French artist-architect Le Corbusier has said "Art is no longer anecdotal, it is a source of meditation after the day's work it is good to meditate" Painters and sculptors have been experimenting and concentrating on patterns and shapes of abstract beauty, or of universal character rather than on literal representation, individual or story interest, where their work possesses such interest it is subordinated to the formal design Everywhere art is simplified, drastically liberated by being stripped of excess and shams There has been a return to the elemental in the endeavour to state the problem afresh

Experiments continue, an immense clearing and productive work has been accomplished which has had the effect of changing all ideas in industrial art since Picasso formulated Cubism (*see* Lesson 22 page 73) Not that it is possible or even remotely desirable, to fetter art to industry, but by such means a synthesis has been arrived at which will be known to history as the style of our period—still, perhaps, in its early stages after thirty years of experiments There is harmony between the new architecture, sculpture and painting, between these great arts and all their decorative dependants—pottery, metal, glass, furniture, mural and textile design

Modern original sculptors, like the painters seeking productive inspiration, have endeavoured to return to the starting point and re-educate themselves They began with the idea of essential sculpture as an activity consisting in the fashioning of form, a work which has sculptural meaning, i e the meaning of its form, need have no anecdotal or sentimental meaning

Ruskin, in "The Seven Lamps of Architecture," tells us:

"I have said that all art is abstract in its beginnings, that is to say, it expresses only a small number of the qualities of the thing represented. Curved and complex lines are represented by straight and simple ones; interior markings of form are few and much is symbolical and conventional."

In some cases sculptors have advanced towards greater completion of their work; in others they have continued of their own free will along the line of what Ruskin terms "noble abstraction," that is, to gather out of objects "those arrangements of form which shall be pleasing to the eye in their intended places," or they have experimented with the essential characters of symbolical life.

Ruskin, over sixty years ago, defined sculpture as "the reduction of any shapeless mass of solid matter into an intended shape," and he displayed a crystal sphere as the essential type of sculptured form in the round (i e. not relief carving); thus—as R. H. Wilenski, in "The Meaning of Modern Sculpture," points out—foreshadowing the modern sculptors' initial creed and their initial concept of form He says:

"They thought of themselves as architects of sculptures in the round; and their first concern was to discover the simplest type of three-dimensional meaning That type they found in the sphere, the cube and the cylinder; and they sought to fashion statues which would be apprehended in the way that the sphere, the cube and the cylinder are apprehended. . . . . And in the early stages they rigorously restricted their studies to this field."

Geometrical Harmony in Art. Greek philosophy has been placed above Greek art. According to Plato's "Philebus," Socrates affirms that geometric forms are not only relatively beautiful, "but they are eternally and absolutely beautiful," while that which is commonly termed art is mere guess-work plus skilful craftsmanship. The sculptors Brancusi and Gaudier-Brzeska (1891–1915) made pioneer experiments in geometrization early in this century. The former, in accordance with the Socratic idea of beauty, has made sculptures which only have meaning as universal or decorative shapes; the latter resolved figures into geometrical forms and also formalized natural structures. Gaudier-Brzeska was killed in the War; three small pieces of his sculpture are at the Victoria and Albert Museum:

"The Fallen Workman," a bronze cast from an early study; a marble torso of a girl, and a statuette in plaster, "The Dancer."

With regard to formalization of natural structures, the modern sculptor shares with the sculptors of the Renaissance the scientific spirit of inquiry. Just as the latter were deeply interested in anatomy and death masks for the purpose of realism, so the former are interested in results of photomicrography. Back to Nature they may go, but from a new and scientific view-point —not the guess-work which Socrates condemned—which has revealed the almost unbelievable perfection of detail in the geometrical construction of organisms. Fossilized skeletons of minute sea-plants—diatoms, for instance—when magnified hundreds of times, show octagonal, hexagonal and pentagonal varieties in absolute symmetry. The spiral curve, which is the plan on which the ammonite shell was developed millions of years ago, has been used throughout the history of art and again appears in modern geometric sculptured compositions.

In his two volumes of series of remarkable photographs, entitled "Art Forms in Nature," Professor Karl Blossfeldt shows that an almost inexhaustible variety of lovely geometrical designs exists in plant organisms. When magnified, all idea of their haphazard growth is dispelled. In his foreword to the second series Professor Blossfeldt says:

"Every sound expansion in the nature of art needs stimulation. New strength and stimulus for its healthy development can only be derived from Nature. . . . . The plant may be described as an architectural structure, shaped and designed ornamentally and objectively. Compelled in its fight for existence to build in a purposeful manner, it . . . . combines practicability and expediency in the highest form of art. Not only then in the world of art, but equally in the realm of science, Nature is our best teacher."

By such studies sculptors have arrived at what Mr. Wilenski (*ibid*) calls "the concept of the universal analogy of form, the concept of all human, animal and vegetable forms as different manifestations of common principles of architecture, of which the geometric forms in their infinity of relations are all symbols"; thus we see that modern sculpture is an effort towards truth to *Life*, and not merely truth to *Nature* in the old individualistic sense. The next generation of sculptors will probably achieve balance by proceeding along more individualistic lines, but they

will have learnt much from these experiments, just as the modern painters learnt much from Cézanne (*see* Lesson 21, page 69).

Although Greek statues are viewed by them without sentimental bias, various modern sculptors have taken a backward glance at Greek art without becoming enslaved in past academic tradition. Aristide Maillol (b 1861), who, with Jacob Epstein, may be termed a transitional master between Rodin and the modern sculptors, went in 1909 to Olympia, there to study the Greek temple fragments, and afterwards to Athens and to Naples. A pupil of Rodin, Maillol reacted against the emotive quality of the great Romantic, but did not become a convert to the antique; his work is modern in his creation of generic and not particular forms. The most famous of his sculptures are the monument to Cézanne and the War Memorial at Elne; various important works are in collections in Germany, where he has had a great vogue, and he has been a constant exhibitor in Paris at the Salon des Indépendants. His French followers are many, and in England Frank Dobson has developed Maillol's work along lines of his own. We owe to Dobson the definition of a work in bronze as a "record of work in a fluid medium—clay."

Zadkine and Archipenko, who are not French but who exhibit in Paris, are other modern sculptors whose work shows traces of Greek affinity as differentiated from Asiatic. They find formal meaning in some of the archaic Greek statues in the round, though the essential cubic or cylindrical shapes of these were borrowed from the Egyptian academic tradition, which was already centuries old when the Greek sculptors used its formula. Picasso, abandoning painting for the time being, has made many interesting experiments in sculpture. He too seems to have looked with his eager and critical gaze at the Greek fragments, as well as at all other plastic forms of the past—to have constructed astounding models for himself from wood and from wire in order to wrench from these new patterns and forms.

Mr. Wilenski tells us that the creative modern sculptors have studied Chinese-Buddhist sculptures, to find that their concepts of plastic form are based on "spheroid, ovoid and cylindrical forms," and their flowing rhythm is accentuated by lines of drapery which are drawn in these shapes. He suggests that if we make our minds a blank, except for the cubic form of Egyptian sculpture, the linear rhythm of the Chinese-Buddhist carvings, and (with several other pietàs) Michelangelo's pietà in St. Peter's,

Rome (*see* Volume 3, Plate 10), then we are in a position to study Epstein's "Night" carved on the Underground Building over St James's Park Station, Westminster

Epstein. Violent controversy has raged round the sculpture of Jacob Epstein (b 1880) since 1907, when he first gained notoriety by his figures for the new buildings of the British Medical Association in the Strand, London, but that his work is the expression of genius of a very high productive order is now generally conceded His clay-modelled busts cast in bronze have found many admirers, because they are merely his own development of the Romantic style of Rodin and, farther back, of Donatello, therefore they have shocked less than his direct carvings in stone, such as "Day and "Night," "Genesis," "Ecce Homo," "Consummatum Est," and "Adam"

Apart from his portrait busts which are Romantic, Epstein has used a negroid or (as in 'Night') a Mongolian facial type in his work, thus giving it an individualistic touch lacking in the more modern work of English sculptors such as Henry Moore, whose carvings in stone and alabaster, 'Girl," 'Mountains' (a study of a recumbent woman) and many compositions are symbols of life Barbara Hepworth, whose Musician" and "Mother and Child" are essays in cubic form, Maurice Lambert, whose Sumerian studies have influenced his direct carving, but who can also produce a poetical abstraction of a yacht

Carvings on buildings form a characteristic part of modern sculpture when they are integral to the building, and not merely modelled figures placed in certain positions as ornaments Epstein's architectural sculpture is carved mainly in the position it is to hold and entirely by his own hand An interesting experiment was made by the English sculptor Eric Kennington at Stratford-on-Avon on the Shakespeare Memorial Theatre with his series of large figure reliefs in brick on brick

Whatever may be the particular reaction to modern sculpture, it is never dull future productions should be yet fuller of interest, with their new developments and efforts to embody the doctrine already expressed in the work of the Chinese artist philosophers of the T'ang age (A D 700): 'We react with satisfaction to works of art which make us realize that all forms in Nature are manifestations of the unity and harmony of Life"

Our Course in Art and Architecture is continued in Volume 5

LESSON 22

Facts and Theories Concerning Comets

(See plates 23 and 24)

THE comets with parabolic orbits are the most numerous, and, together with those possessing what appear to be hyperbolic orbits, the most mysterious. As these bodies sually only become visible somewhere within a limit of about 150 million miles, we may never even know the existence of all those with a perihelion distance beyond this. The greater proportion of these comets, about 63 per cent, come within the earth's orbit, and another 30 per cent between the orbits of the earth and Mars to perihelion.

Now, since about 300 new comets of this class (as distinct from the periodic comets considered in Lesson 21, Volume 3, page 104) are discovered in a century, with a tendency to increasing numbers, the total must amount to several thousands. The all-important question is whether they ever return. The relatively small portions of their orbits which are observable permit of the possibility that, instead of parabolas, they may be extremely elongated ellipses, in which their outward and return paths are almost parallel. This is, of course, *relative to the sun*, but since the sun, together with the whole solar system, is travelling very rapidly in a certain direction in space, we realize that, *relative to space*, these comets' orbits would be far from parabolic. They might, therefore, be ellipses if they return, or hyperbolas if they do not.

Now, it so happens that there are about 20 comets whose orbits are apparently hyperbolic. When, however, account is taken of the deviating attractions of the greater planets, particularly Jupiter and Saturn, it is found that the comets' paths, which may have originally been ellipses, have been distorted in approaching the sun into hyperbolas, and into what appear to be hyperbolas as they recede from the sun, whereas actually the orbits are ellipses, and so the comets will eventually return.

Thus, the evidence inclines toward all comets being an integral part of the solar system, and, consequently, the old belief that the parabolic and hyperbolic comets travel across space from

star to star and visit our sun but once, is improbable. If all comets can be regarded as members of the sun's family, the problem of their origin will be helped toward some solution.

That comets are celestial bodies and not intangible phenomena is proved by their being governed by the force of gravitation. Therefore, they must have mass; this has been found to be very small in proportion to their volume or bulk, and though it has not been found possible to measure a comet's mass definitely, it is certain that the largest comets do not contain more material in their composition than could be condensed into a sphere 10 miles in diameter. This small mass has been proved by the fact that comets exercise no perceptible perturbing or deflecting force on the planets, whereas the latter produce great perturbations upon comets.

Nearly all the body of a comet is contained within its nucleus, that is, the bright centre within its head or coma. Comets shine partly by reflected sunlight, but are to a certain extent self-luminous. Moreover, while the coma and nucleus, if any, obey the laws of gravitation, the tail does not. This always curves and floats away into space in a direction opposite to the sun's attraction; hence as a comet recedes from the sun after perihelion, its tail always precedes it. A comet may have more than one tail—perhaps three or four extending fan-shaped or as curved streamers, this effect being produced by the comet's motion.

Composition of the Tail. The tail appears to be composed of exceedingly minute particles of matter generated by the comet in the form of highly rarefied gas. The particles are so small and light that the radiation pressure of the sun's light is greater than the sun's gravitational pull; they are thus driven away into space, causing a continuous loss to the comet. The particles composing the tail are seen being produced in bright comets from the head as jets of light or as hollow luminous rings; the processes are often well shown in photographs of comets. The tail is frequently absent from smaller comets—as if all the finer particles which might enter into its composition had been lost. On the other hand, a comet may develop a large tail and also a brilliant nucleus, originally absent, as it approaches the sun, the brightness of the comet increasing as it nears the sun.

There is always a more or less globular head or coma, which, in a typical comet, contains a bright nucleus; but in many instances, particularly in small comets, the nucleus may be

absent and replaced by a more diffuse condensation, as shown in the picture of Encke's comet in Volume 3, Plate 24. Occasionally the condensation is absent, particularly when the comet is at a great distance from the sun; then the comet will frequently develop a nucleus as it approaches the sun, and go through fluctuations of brilliancy with successive outbursts of material which expand the tail. In a few exceptional instances the nucleus has been seen to become double (and even quadruple in the case of the Great comet 1882 III), but in these cases the phenomenon precedes division of the comet.

Dimensions. The dimensions of comets impress us by their vastness. The head of Halley's comet had at one time during its last visit a diameter of 550,000 miles, two-thirds that of the sun; but this had varied between 30,000 and 220,000 miles during most of its visibility while approaching and receding from the sun. The head of the Great comet 1811 I was over a million miles in diameter—that is, it was much larger than the sun. On an average the heads of comets are between 10,000 and 150,000 miles in diameter.

The nucleus within the head or coma is much smaller, often not more than 100 miles in diameter. The nucleus of the Great comet 1811 I was only 428 miles at one time, while that of Halley's comet was only about 500 miles across. The nucleus of the Great comet 1882 III, before it divided, was 1,800 miles in diameter—one of the largest known. Donati's famous comet 1858 VI had a nucleus only about 630 miles across at a time when its tail was 45,000,000 miles in length. As with other parts of a comet, the nucleus varies considerably in size as it progresses in its path toward the sun. The nucleus of Donati's comet, for instance, varied between 5,000 miles and only 400 in width, shrinking as it neared the sun, but at the same time greatly increasing in brilliancy. The tail, on the other hand, expanded enormously. This comet had an elliptical orbit; it is expected to return in about 2,000 years. We see that the dimensions of comets vary considerably. The Great comet 1811 I had a tail over 100,000,000 miles long, so it would have stretched farther than from the earth to the sun. The tails of the Great comet 1882 III were 60,000,000 miles long, with a diameter reaching to 15,000,000 miles. Their volume must have been colossal, yet stars will shine through all this cometary material with undiminished lustre; from this we gain some idea of their

tenuity. Schwarzschild calculated that there could not have been more material in 2,000 cubic miles of the tail of Halley's comet than there is in a cubic inch of ordinary air.

Composition of the Nucleus. The nucleus is much more substantial, spectroscopy revealing the presence of nitrogen, cyanogen, hydrocarbons, carbon monoxide and radiations of sodium and iron when the comet is nearer the sun. These gases do not represent all the materials composing the nucleus, but only the radiant product of the commotion, friction or combustion taking place in the nucleus. There is good reason for regarding most of the elements with which we are familiar as entering into the composition of comets. This will be explained when we deal with meteors, and also why the nucleus of comets is now regarded as composed of innumerable discrete particles ranging from the size of grains and marbles to masses a hundred feet or more in diameter. How close all these particles are together or what is the nature and speed of their movements, to produce the intense luminosity when near the sun, the emission of gases and the material for their gigantic luminous tail, can only be inferred from the meteoric matter into which comets have been found to disintegrate.

Division and Dissolution. There is no doubt that comets gradually waste away; they also part asunder and thus deteriorate; this process was witnessed in the case of the Great comet 1882 III, also in that of Taylor's comet 1916 I, a Jovian comet of short period, and of Brooks' comet 1889 V, which passed so close to Jupiter that it became divided, the two parts separating and following short 7-year orbits between Jupiter and the sun instead of the previous 27-year orbit. This was a clear case of "capture," as it is called, by Jupiter, which may account for all the Jovian "family" of comets. There are other instances of comets dividing and even vanishing in consequence. The most noteworthy is Biela's comet, which was seen to become double in 1846; it returned in two parts in 1852 and then vanished. Its period was about 6¾ years. It should, therefore, have appeared several times since, but, instead, a brilliant meteoric display was witnessed when the earth crossed its path. Remnants of this comet are thus still met with as meteors, and destroyed in the earth's atmosphere each November.

While comets thus dissolve and vanish their origin is still a problem. One theory is that the material of comets originated

in a meteoric or cosmic dust cloud a million or so years ago, and that the solar system in its journey through space passed through such a cloud. Another more probable theory is that comets represent material ejected from the sun and planets millions of years ago, when their eruptive activity was far more violent than now. Yet another suggested solution is that comets originate in a vast quantity of exceedingly rarefied material encircling the outer periphery of the solar system, many times beyond the orbit of Neptune, to include the orbits of comets with periods approaching 10,000 years. At such distances the speed of a comet would amount to only a few yards a second; this would slowly increase, until a speed approaching 30 miles a second would be attained as it passed the earth's orbit. On nearing the sun this would rapidly increase in proportion to the nearness of the comet's perihelion to the sun's surface. Comet 1882 III, for instance, sped round the sun with a velocity of 300 miles a second.

The possibility of a comet's nucleus striking the earth must be admitted, but from elaborate calculations the chances would appear to be one in many millions of years. Then such collision would amount to no more than a local and dense fall of meteorites. There are evidences of such falls having occurred; these will be discussed in a succeeding Lesson under meteorites.

LESSON 23

Meteor Showers of the Night Sky

(See plate 24)

Meteors produce the streaks of light occasionally to be observed shooting across the night sky, and are therefore popularly known as "shooting stars." They are not stars, however, and in reality they do not shoot but fall Sometimes one or more of these bodies will reach the earth's surface before being completely destroyed. Such bodies are known as meteorites or aerolites.

It is possible to see an occasional meteor on any dark, starlit night when the moon or artificial lights are absent, but on more rare occasions a meteor will appear as bright as Venus or Jupiter and last for 2 or 3 seconds, leaving a luminous train, which will remain sometimes for a minute or two. Still more rare are those

splendid meteors which sometimes rival the full moon in brilliance, light up the landscape and have even been seen in daylight; these are usually known as *fire-balls*, a term which must not be confused with the electric phenomena associated with thunderstorms.

These different types of meteors have not the same origin, though they are all individual bodies travelling freely through space and from distances amounting to many hundreds of millions of miles—in some cases, thousands of millions—far beyond the orbit of Neptune. Consequently, there is a great interest attaching to bodies which have travelled so far and arrived in such numbers, eventually to become part of the earth.

While speeding through interplanetary space, meteors are invisible on account of their small size; they only appear after penetrating the earth's atmosphere, and when they are at a height of between 80 and 100 miles above the earth's surface. Then they become visible through ignition, in consequence of the heat generated by friction against the air, which is intense at the speed with which they are travelling—and, as a rule, the meteor is consumed.

Speed of Meteors. The average speed at which the meteors travel when near the earth is about 26 miles a second, but this, as observed by us, may be increased relatively, owing to the fact that the earth travels at about 18½ miles a second. Consequently, if our world and the meteors are approaching head on, as it were, the observed speed may amount to over 40 miles a second On the other hand, the speed of meteors approaching the earth obliquely, or from the rear, will seem relatively much slower, their apparent velocity being only a few miles a second. Such meteors are more likely to reach the earth's surface, since their combustion is slower; they usually appear reddish and less bright. The meteors which do not reach the ground may disappear at any height; since most of them are very small they vanish when between 50 and 30 miles above the surface, after travelling along a path which, though it averages only 30 miles through the air, may, in the case of large meteors, be over 200 miles in length

While the number of meteors counted by a single observer on a fine dark night may amount to between 6 and 8 an hour, on some nights this may be increased, until at certain well-known times it can exceed 60 meteors an hour. Though the arrival of the large individual meteors cannot be predicted, yet there are

nany meteor swarms or showers which appear with a periodicity that can be foretold to within a day or two.

Meteor Radiants. The meteor swarm of a particular period will be seen to come from a certain spot in the sky if the meteors be traced back to their first appearance. This point is called the *radiant;* it is the same for all observers, and represents the direction from which the meteors approach the earth before they enter its atmosphere. Therefore, each swarm of meteors has its own particular radiant, the meteors from which are named after the constellation in which the radiant is situated—as, for instance, the Leonids, from Leo. Sometimes, when more than one radiant is known to be in a constellation, it is named after a particular star which appears near by, such as the Alpha Leonids, which are distinct from the above. The stars have no connexion whatever with the meteors.

The meteor radiant is defined according to degrees in right ascension and declination on the celestial sphere. These are the imaginary lines which correspond to those of longitude and latitude respectively on the terrestrial sphere. The whole of the meteors from a particular radiant are known as a meteor swarm, and each swarm has its peculiarities in addition to the date of appearance; some are swift meteors, those from other radiants slow, while some swarms are reddish others bluish. The most notable meteor swarms, together with the dates about when they appear and the radiant point of each, are listed in a table in the next page. The Greek letters indicate the star after which the radiant is named.

The dates of the radiants given in the table may vary by as much as a day—this is usual in leap years; moreover, the position of the radiant in some cases is known to move slightly during the display. Altogether, about 1,200 radiants are known.

If any one swarm or *shower* (as it is called when the display takes place) be watched throughout the night, the number of meteors seen usually increases towards the morning hours; the observer is at that time nearer the *apex* or direction of the earth's motion in her orbit. He is, as it were, then at the front of the earth, whereas in the evening he is at the rear, and the effect is comparable to the greater number of raindrops caught in front by a person advancing against a downpour.

Meteor Showers. Quite the most remarkable among the meteor swarms are the Perseids, Leonids, Andromedids, Lyrids,

METEOR SHOWERS

Date	Meteor Swarm	Right Asc.	Declination
January 2–4	Quadrantids	231°	53° North
January 29	κ Coronids	230°	25° North
February 10–13	λ Hydrids	147°	11° South
February 22–28	α Leonids	155°	14° North
March 1–4	τ Leonids	166°	4° North
March 11–12	ζ Bootids	218°	12° North
March 24	β Ursids Major	161°	58° North
April 10–13	ζ Bootids	210°	13° North
April 20–22	Lyrids	271°	33° North
April 21	Herculids	274°	25° North
May 2–6	γ Aquarids	337°	1° South
May 11–18	α Coronids	231°	27° South
May 30	η Pegasids	333°	27° North
June 3–7	α Scorpiids	252°	22° South
June 27–30	η Draconids	245°	64° North
June 27–30	Pons-Winneckeids	213°	53° North
July 7–11	α Pegasids	343°	12° North
July 24–26	α Capricornids	305°	12° South
July 27–31	δ Aquarids	339°	11° South
July 30–August 3	γ Andromedids	23°	42° North
August 10–12	Perseids	46°	57° North
August 11	μ Perseids	61°	48° North
August 10–16	θ Cygnids	293°	53° North
August 16	α Lyrids	284°	44° North
August 21–25	ο Draconids	291°	60° North
August 21–25	γ Pegasids	6°	11° North
September 3–4	α Cygnids	315°	48° North
September 4	γ Piscids	348°	2° North
September 6	ε Perseids	61°	36° North
September 21–22	η Aurigids	75°	41° North
September 22	μ Perseids	61°	48° North
September 27	ε Piscids	14°	6° North
October 8	ι Aurigids	77°	33° North
October 9	β Draconids	264°	55° North
October 15–16	ξ Arietids	31°	9° North
October 17–22	Orionids	92°	15° North
October 21–23	α Cetids	45°	6° North
October 29–Nov. 2	ε Arietids	43°	22° North
November 5	c Perseids	61°	35° North
November 15–16	Leonids	152°	22° North
November 17–23	Andromedids	25°	43° North
November 26–28	μ Ursids Major	155°	36° North
November 28	κ Taurids	63°	22° North
December 7–9	ζ Taurids	81°	23° North
December 11–14	Geminids	113°	32° North
December 22–23	δ Cancrids	130°	19° North
December 31	θ Geminids	104°	33° North

γ Aquarids, η Draconids and α Capricornids These have on many occasions provided superb displays The Perseids, once known as the Tears of St Lawrence, are to be seen from midnight, when their radiant is low in the north-east, throughout the night until between 3 and 4 a m , when the radiant is almost overhead and the meteors appear to fall from the zenith They are very swift, usually small and their paths short, an average of 60 an hour being often counted at their annual display, while at times this will be doubled Although the maximum occurs at some time between August 10 and 12, yet some of these meteors are to be seen 3 or 4 weeks beforehand The position of the radiant, which changes from night to night, is given in the preceding page for the date of maximum display

The Leonids have provided the most famous of all meteor showers The first record of their having been observed is in A D 902 and records since then show that the shower came in greater brilliancy and profusion thrice a century Every year a few of the swarms are to be seen they are low in the east about midnight, their numbers considerably increasing afterwards until they attain their maxima about 5 a m Then they appear high up in the south These meteors have not been very numerous in recent years, but on some historic occasions the display has been superb In the year 1799 they resembled fireworks from a celestial fountain, pouring from the radiant and spreading out over the sky This appearance is the effect of perspective, for actually the meteors travel in parallel paths In 1833 this grand shower was repeated, 200,000 an hour being the estimate of some observers—and this for but one position with a limited view of the whole The display lasted about six hours

An expert investigator, H A Newton, predicted in 1864, from a study of past records, yet another return of this Leonid swarm to take place on November 13 or 14, 1866 It came true to time, and was in a lesser degree repeated in the following year Then J C Adams, of Neptune fame, computed the orbit of this meteor swarm, and found that the meteors travelled in a long stream over a very elliptical orbit, a more concentrated mass of the meteors constituting the grand swarm These cross the earth's path every 33 to 34 years, when our world is in their vicinity, the meteor shower being the effect of numbers of them colliding with the earth's atmosphere.

PICTURES BY THE PRE-RAPHAELITE LEADERS. Above, left, is " The Annunciation " painted by Dante Gabriel Rossetti (1828–1882), with its formal and beautiful design. Right : " Claudio and Isabella," by Holman Hunt (1827–1910), a harmony of dramatic appeal and decorative pattern. Below is the " Ophelia " of Sir John Everett Millais (1829–1896), jewel-like in its brilliance of colour. ART AND ARCHITECTURE 19

Top left and bottom, National Gallery; top right, Tate Gallery, London

·AUTY OF SPRING AT BARBIZON. Jean-François Millet (1814–75), whose ·istic art was poetic and not objective, was the son of a peasant and famous his pictures of French peasant life. He worked chiefly at Barbizon, where "Le Printemps" (above) was painted. ART AND ARCHITECTURE 20

The Louvre

ATMOSPHERIC ART OF COROT. Prominent among the members of the Barbizon school was Jean Baptiste Camille Corot (1796–1875), whose work is characterised by perfection of technique. "A Flood," reproduced above, is a typical example of his later landscape manner. ART AND ARCHITECTURE 20

National (Tate) Gallery, Millbank

It was expected that the shower would be repeated in 1899 or 1900, but the results were disappointing, except that early on the morning of November 15, 1901, many thousands of the meteors were observed in the western States of North America. It is feared that the main swarm has been deflected by Jupiter and other planets. More recently fifty Leonids an hour were counted, although the moon was present; this was the normal annual display.

LESSON 24

Some Facts about Meteoric Bodies

(See plates 25 and 26

METEORITES, or, as the larger specimens are often called aerolites, are those fragments of meteoric material which survive entire combustion and reach the earth's surface more or less intact; in many cases they are subsequently found deeply embedded in the ground. Large luminous bodies of this class, while travelling through the sky, are sometimes called bolides and fireballs. The meteorites are always the remains of these large bodies; a considerable portion of their material has become vaporized and entered the atmosphere as gases and dust during their swift incandescent passage to the ground. If their velocity is greater than about six miles a second the frictional resistance of the air will generate this incandescence, and since the speed at which they enter the atmosphere usually far exceeds this—amounting in many instances to about forty miles a second—the heat generated and the consequent loss of material are considerable: in this way, only a residue of the less combustible elements is left, which accounts for meteorites being such heavy bodies. Much of the vaporized material enters into the composition of the earth's atmosphere as gas, while a proportion subsequently falls as meteoric dust; in Arctic regions this dust is perceptible and may be collected from the snow. Thus it will be seen that there is a constant accretion by the earth of meteoric matter.

Fireballs. In the case of the large spectacular meteorites commonly called fireballs, the period of incandescence is too short to consume more than an outer layer, the interior being unaffected if the fireball remains intact. Fireballs have even been found

quite cold soon after reaching the ground. The length of time occupied by these solitary fireballs in their flight will often amount to several seconds, their paths frequently reaching to between 100 and 2,000 miles in length. Their progress is often irregular, while becoming perceptibly slower owing to air resistance; ultimately, it may be less than 10 miles a second. The spectacle is occasionally very fine, as the meteoric fireball strews its path with sparks of varied colours and lights up the landscape as brightly as the full moon; sometimes fireballs rival the moon in apparent size. A roar or thunderous sound frequently follows their appearance, and, since some of them explode, they are known as detonating and bursting meteors. They usually leave a trail behind, produced by the hot luminous vapours given off in their flight; this may last for several minutes, or longer in exceptional cases. Therefore, their paths may be measured with exactitude, and their height, vanishing point and size calculated from various observations at different points, by two or more observers of the same object.

Between four and five are to be observed annually in one locality; from this it is to be inferred that the actual number of these large meteoric fireballs, which annually become part of the earth, must amount to thousands. The great majority will fall in the sea, as it is so much larger than the land, while only a very few of those which are seen to fall are ever recovered; nevertheless, many thousands have been collected, and are in various museums and private collections of the world. These are chiefly the heavy metallic meteorites, sometimes called siderites, which, owing to their weight and crystalline exterior, are more easily recognized, whereas the stony meteorites, which actually constitute the great majority of the recovered particles of the meteorites seen to fall, will, unless their position is noted, often get lost or overlooked through appearing as common stones.

Notable Meteorites. The following are the most notable recent examples. An exceptionally fine meteorite was observed early in the morning of March 24, 1933, in Mexico, Texas, Kansas, Arizona and Colorado. It first appeared at a height of about 65 miles above Oklahoma State, and disappeared at a height of between 6 and 8 miles over a point in the State of New Mexico. Its detonations were heard in five States; they were accompanied by a roar likened to artillery, rattling of windows and vibrations of the ground.

On October 9, 1933, a fine display of meteors followed the return of Giacobini's comet of 1900, which seems to indicate that meteor swarms accompany disrupted comets. On January 3, 1935, a brilliant fireball was seen at a height of 55 miles over the English Channel, 23 miles south of Christchurch, passing 20 miles above Wotton-under-Edge, Glos. It was described as being brighter and larger than the full moon and producing a chain of sparks visible for nearly three seconds. As during this time it travelled 92 miles, it was a slow fireball; it changed colour and finally broke into two pieces A detonation was heard at Bradford-on-Avon due to the meteor's rush giving rise to shock waves sounding like thunder. A shower of brilliant meteorites was seen in Southern Sweden during the evening of May 27, 1938, together with two extraordinarily bright fireballs. As will be seen from the table of radiants there is no shower known for this day. But it may be that this display was due to a stream which had been perturbed and thus met the earth's orbit. On October 2, 1938, a fireball was seen for 30 seconds from Brittany, about the size of the full moon and with a red trail.

Metallic and Stony Meteors. The meteorites or aerolites have very often, after cooling, a crystalline exterior, and are covered with what appears to be a black carbonized glaze; this is the result of surface fusion and subsequent rapid cooling. There are two characteristic varieties, the metallic or "iron" meteorite, and the uranolith or "stony" meteorite The metallic examples are usually composed of masses of iron, together with nickel, cobalt, magnesium and other elements The stony examples are masses of crystalline rock, and these masses often possess peculiar crystals of familiar elements, such as limestone, magnesia, and siliceous stone; faulting veins, fragmentation and recementation are frequently perceptible, serving as indications that the meteorites were composed of old rocks and material blown out of volcanoes, or were the particles of a disrupted world. Some possess a large admixture of iron. Altogether numerous elements have been found in meteorites; these are chiefly iron, nickel, oxygen, silicon, magnesium, sulphur, calcium, cobalt, aluminium, sodium, and even argon and helium, while hydrogen, nitrogen, carbon monoxide, hydrocarbons and phosphide of iron are present in different chemical combinations.

Meteorites in History. The most notable meteoric masses are to be seen in museums. The South Kensington Museum,

for instance, possesses a very fine collection; one specimen weighing about 3½ tons was found at Cranbourne, near Melbourne, Australia, in 1854. One of the oldest meteorites of the fall of which there is an authentic record is in the parish church of Ensisheim, in Alsace, suspended by a chain. The record states that on November 16, 1492, a crash of thunder and prolonged noise were heard, while a stone weighing 260 pounds was seen by a child to fall in a field, making a hole more than 5 feet deep. The black stone of Mecca, in the sacred Kaaba, is another ancient meteorite. The primitive "image" of Diana at Ephesus, which was regarded as having fallen from the god Jupiter, was doubtless another meteorite. A Chinese record of 616 B.C. refers to a meteorite which killed 10 persons. Livy mentions a fall of meteorites as occurring about 650 B.C. This was accompanied by "a mighty noise." The astronomer Gassendi saw one fall in 1627 which weighed 59 pounds, this was in Provence. The largest single mass was found in Greenland, and brought from Melville Bay by Peary for the Museum of Natural History in New York; it weighs 37½ tons. Another large specimen was found in Brazil, weighing 6 tons; while one still remains in the ground in Mexico weighing about 60 tons. One of the largest found in Britain fell in Yorkshire in 1795, weighing 56 lb. In 1914 a meteoric mass fell near Wigan, weighing 33 lb., and another near Perth in 1917, weighing 38 lb.

These bodies do not always travel singly; occasionally the fireball consists of large numbers of usually smaller bodies, all massed together. Such a fall occurred at Pultusk, in Poland, on January 30, 1868, when over 100,000 were estimated to have fallen. In 1510 a large number fell near Padua, some weighing up to 100 lb. Between 2,000 and 3,000 aerolites fell at L'Aigle, in France, on April 26, 1803. At Mocs, in Hungary, on February 3, 1882, over 100,000 were estimated to have fallen. About 14,000 fell in Arizona on July 19, 1912. Most mysterious and devastating was the fall which apparently occurred on June 30, 1908; though the fall was not actually observed, a very brilliant light was seen in the sky from the east of Scotland and elsewhere in northern Europe. Even at Greenwich a strange glare was noted, resembling the dawn, while many places reported the period before midnight becoming as light as day. Subsequently, it was found that peasants in Siberia reported a great explosion, earth-shock and earthquake vibrations north of Irkutsk, where

there was much destruction. Finally, the area was explored in 1927, and a group of meteor craters were found containing at least 130 tons of meteoric stones. The forests for 40 miles from the scene were destroyed, the trees being laid flat.

Most famous of all evidences of past meteoric falls is the great meteor crater in Arizona, situated near Winslow and the Cañon Diablo, far from all volcanic activity. It presents a depression 600 feet deep and about 4,500 feet in diameter; thousands of iron meteorites have been found, and doubtless large numbers remain buried beneath the crushed masses of rock. Another crater is known in Texas 530 feet in diameter, while a group at Henbury, in Australia, has one crater about 600 feet in diameter. Others are now being discovered annually in unfrequented areas of the earth, and are the subject of exploration.

LESSON 25

Unsolved Problems of the Solar System

(See plates 27 and 28

In the preceding survey of the various bodies that constitute the solar system, we have considered all those which are individually visible and may be studied as separate units of the grand whole, but there remain certain phenomena which cannot be so studied. The most notable of these are the zodiacal light and the *Gegenschein*.

The zodiacal light may be observed in the west soon after twilight has vanished, and also in the east just before dawn. It produces a faint cone of light, appearing in these latitudes more or less tilted, as shown in the illustration in plate 27. This cone of light is best seen in the evenings in spring, when it slopes upwards toward the left from where the sun has set. In the mornings it is best seen in the early autumn, when it will slope towards the right from about where the sun will rise later. A clear and fairly dark moonless sky is necessary to reveal the cone of pearly zodiacal light. It is brightest near the horizon, and actually extends to about 45 degrees from the sun—which, however, has to be some distance below the horizon before the light becomes perceptible. Much depends upon the clearness of the atmosphere and the angle which the cone subtends to the

horizon; hence spring and autumn are best for observation, for then the cone of light is nearer to perpendicular than in summer or winter, since it follows the angle of the ecliptic, or zodiac.

Origin of Zodiacal Light. This singular light has been found, spectroscopically, to be the same as sunlight reflected from the moon, and, like it, it is partially polarized. Thus it is evident that the zodiacal light is reflected from solid particles obviously too small to be perceptible, even through most powerful telescopes. Close observation in tropical lands has shown that the light in a very faint degree extends over the entire sky—more intensely along the line of the zodiac—and links up with a small replica of the zodiacal light. The latter is the *Gegenschein*, which appears in the opposite side of the sky and covers an area about 10 degrees in diameter. The centre of this *Gegenschein*, or "counter-glow," is directly opposite the sun.

Thus it becomes evident that there exists a large lenticular-shaped belt of small bodies or particles encircling the sun and extending to beyond the earth's orbit; the zodiacal light is that which is reflected from the particles within the circumference of the orbit, while the light of the *Gegenschein* comes from particles outside its circumference. They must be exceedingly small, approximating to meteors in size, and on an average several miles apart—otherwise the combined mass would sensibly affect the motions of the earth, Venus and Mercury in their orbits.

Matter from Space. When we consider the myriads of these particles, together with the innumerable meteors which are speeding in some thousands of streams along their elliptical orbits to and from the sun, we realize that interplanetary space is far from being empty, although visually it appears so. It has been calculated by Professor Newton that 20,000,000 meteors large enough to be visible to the naked eye enter the earth's atmosphere every day and thus become part of our world. Hence there is a constant accretion of material, which must result in the gradual growth of this and other planets. This material has been calculated to amount to about 36,500 tons per annum on an average—that is, assuming that something like 100 tons fall on the earth every day from the 20,000,000 meteors. These estimates, though necessarily vague, are based upon observed facts, and we find that even the deposition of this amount of material would require, according to the calculations of Professor

Young, about 1,000,000,000 years to accumulate a layer one inch thick over the earth's surface. Planetary growth is, therefore, by this means exceedingly slow nowadays, but it may not have been so in the distant past, when quite possibly meteoric matter was far more prolific than at present.

Origin of Meteors. We are now at the threshold of the problem of the origin of the earth, planets and solar system generally. Have the planets grown by the accretion of meteoric matter through the long aeons of time? If they have, whence have come the meteors? It has been found that some meteor swarms represent disintegrated comets, others the residue of known comets. For example, the residue of Tuttle's comet of 1862 produces the Perseid meteors of August 10–12; the Leonids of November 15–16 are the residue of Tempel's comet of 1866; the Andromedid meteors of November 17–23 have proved to be the disintegrated Biela's comet, which was seen to part asunder and has since vanished. The Aquarids of May 2–6 are the residue of Halley's comet, while the Pons-Winnecke comet appears to be responsible for the Draconids of June 27–30 and the Comet 1881 V for the Capricornids of July 24–26. It appears that the nucleus in the head of a comet is composed of a great concentration of meteoric bodies or particles, all probably in violent commotion, their concentration and consequent concussions increasing as the comet approaches the sun.

It may, therefore, be inferred that all meteor streams are the product of cometary disintegration. Now if it could be proved that all comets originally entered the solar system along hyperbolic paths from outer space, paths which were subsequently transformed in many cases into elliptical paths, we would have a possible source of the meteoric material from which, in the course of ages, the planets have grown. This, in brief, is the meteoric theory of the growth of worlds and systems.

There are other theories which approach this problem from different standpoints of ascertained facts, and even to the extent of accounting for the origin of the planets and their remarkable series of similarities—such as their common direction of orbital motion, rotation, the closeness of the planes of their orbits, the singular sequence of their proportionate distances from the sun as represented by Bode's Law, together with the way in which the sun's equator and its rotation conform to those of the revolving planets.

Laplace's Hypothesis. The nebular hypothesis of Laplace is the oldest and best known of these theories, and may be described as follows. Suppose that we have a nebula or cloud of primordial luminous mist—say, some 6,000,000,000 miles in diameter. This nebula must be subjected to two distinct causes of change. First, all its material particles must attract one another by the law of gravitation, so that the nebula tends to condense towards the centre; simultaneously, the luminous or incandescent particles composing the nebula would be constantly radiating heat out into space. Such a nebula could not for a moment remain at rest, even if it was originally in such a condition—which is practically impossible. For, as it gradually radiated its heat, it would contract; and, having acquired a rotation about an axis, this would gradually become more rapid, to preserve its angular momentum. Finally, the speed near the edge of the rotating mass would overcome the pull of gravity sufficiently for this to resist further shrinkage and a separate ring of matter would become detached and continue rotating under its own centrifugal force. Subsequently, other rings would form in the same way at regular intervals. The material of the rings would under various gravitational perturbations tend to coalesce in masses, finally forming spherical bodies or planets, which would continue to revolve round the central nucleus that eventually condensed into the sun. Each of the revolving masses, while hot enough to preserve its nebulous condition, and having acquired a rotation from tidal attraction of the central mass, would, when rapid enough, also shed minor rings, which in time would form spheres or satellites (except in the case of part of Saturn which formed the rings). The asteroids or planetoids might also be regarded as an instance in which the nebulous ring failed to coalesce into a planet.

The theory has been found to have two objections: first, that the rings would not coalesce into single large bodies but into numerous very small ones; secondly, that if the nebula was rotating at such a rate as to throw off the outer ring, the sun's present speed indicates that it is far too slow for it to have thrown off anything in that distant period.

The Tidal Theory. The tidal theory, or, as it is technically termed, the Hypothesis of Dynamic Encounter, is a more recent explanation, which has grown in favour during the last 30 years. It assumes that the sun was at one time without planets; then

another sun, or "wandering star," approached sufficiently near to raise enormous tides on our sun. These tides, reaching many thousands of miles in height, resulted in the material being finally drawn away from the sun. The illustrations in Plate 27 give a good idea of the suggested process and the ultimate evolving of the planets as a consequence. The "wandering star's" attraction would tend to impart a motion to the original mass in a direction similar to that in which the star was travelling, and thus the "embryo" planets would begin travelling in what was later to become their orbits. This hypothesis thus explains the angular momentum or speed possessed by the planets in their orbits, and also accounts for the sun's rotation in harmony therewith.

Sir J. H. Jeans thus summarizes the situation in the light of recent discoveries: "The tidal theory is generally accepted by astronomers as depicting the most probable method of birth of planets. The theory is quite recent, and cannot claim any sort of finality yet. It is, nevertheless, the only theory at present in the field which can claim to be described as even plausible, all other theories having been convicted of insuperable objections."

LESSON 26

Ancient and Modern Star Groupings

THE nature and constitution of the stars are, more or less, similar to our sun, which, however, is a star far advanced in stellar evolution, and therefore much smaller than most other stars. About 2,000 can be seen at one time over the half of the heavens visible on a very clear and dark night, but haze and the presence of artificial lights normally reduce this number to less than half; field-glasses will increase the number to twenty or thirty thousand; to these must be added about half as many again, which are below the horizon and will come into view in due course. There are also about 25 per cent more which are for ever out of sight in Britain, but which may be observed from southern latitudes. The telescope greatly increases the number visible with each increase of power, until about a thousand million are revealed by the most powerful instruments, and many more are known to exist in masses in

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LIST OF CONSTELLATIONS AS DEFINED BY THE

English Name.	*Latin or Greek Name.*	*Genitive Form.*	*Abbreviation.*
Chained Lady	Andromeda	Andromedae	And.
Air Pump*	Antlia	Antliae	Ant.
Bird of Paradise*	Apus	Apodis	Aps.
Water Bearer	Aquarius	Aquarii	Aqr.
Eagle	Aquila	Aquilae	Aqi.
Altar	Ara	Arae	Ara.
Ship Argo	Argo	Argûs	Arg.
Ram	Aries	Arietis	Ari.
Wagoner	Auriga	Aurigae	Aur.
Herdsman	Boötes	Boötis	Boo.
Sculptor's Tool*	Caelum	Caeli	Cae.
Giraffe*	Camelopardus	Camelopardi	Cam.
Crab	Cancer	Cancri	Cnc.
Hunting Dogs*	Canes Venatici	Canum Venaticorum	CVn.
Dog	Canis Major	Canis Majoris	CMa.
Lesser Dog	Canis Minor	Canis Minoris	CMi.
Sea-Goat	Capricornus	Capricorni	Cap.
Lady in the Chair	Cassiopeia	Cassiopeiae	Cas.
Keel* (of Argo)	Carina	Carinae	Car.
Centaur	Centaurus	Centauri	Cen.
Monarch	Cepheus	Cephei	Cep.
Sea-Monster	Cetus	Ceti	Cet.
Chameleon	Chamaeleon	Chamaeleontis	Cha.
Compasses*	Circinus	Circini	Cir.
Dove*	Columba	Columbae	Col.
Berenice's Hair*	Coma Berenices	Comae Berenicis	Com.
Southern Crown	Corona Australis	Coronae Australis	CrA.
Northern Crown	Corona Borealis	Coronae Borealis	CrB.
Crow	Corvus	Corvi	Crv.
Cup	Crater	Crateris	Crt.
Cross (Southern)*	Crux	Crucis	Cru.
Swan	Cygnus	Cygni	Cyg.
Dolphin	Delphinus	Delphini	Del.
Sword-Fish*	Dorado	Doradûs	Dor.
Dragon	Draco	Draconis	Dra.
Little Horse	Equuleus	Equulei	Equ.
River Eridanus	Eridanus	Eridani	Eri.
Furnace*	Fornax	Fornacis	For.
Twins	Gemini	Geminorum	Gem.
Crane*	Grus	Gruis	Gru.
Hercules	Hercules	Herculis	Her.
Clock*	Horologium	Horologii	Hor.
Sea-Serpent	Hydra	Hydrae	Hya.
Water-Snake*	Hydrus	Hydri	Hyi.
Indian*	Indus	Indi	Ind.

NOTES. The asterisk in the list indicates that the constellation is a modern grouping, since 1600. The great constellation of Argo has been divided into Carina, Puppis, Vela and Malus; the latter is now usually called Pyxis. In these divisions Argo, the Ship, is most generally known. Sobieski's Shield has only recently been generally recognized;

INTERNATIONAL ASTRONOMICAL UNION IN 1922.

English Name.	*Latin or Greek Name.*	*Genitive Form.*	*Abbreviation.*
Lizard*	Lacerta	Lacertae	Lac.
Lion	Leo	Leonis	Leo.
Lesser Lion*	Leo Minor	Leonis Minoris	LMi.
Hare	Lepus	Leporis	Lep.
Balance	Libra	Librae	Lib.
Wolf	Lupus	Lupi	Lup.
Lynx*	Lynx	Lyncis	Lyn.
Lyre	Lyra	Lyrae	Lyr.
Mast* (of Argo)	Malus or Pyxis	Mali	Pyx.
Table Mountain*	Mensa	Mensae	Men.
Microscope*	Microscopium	Microscopii	Mic.
Unicorn*	Monoceros	Monocerotis	Mon.
Bee*	Musca	Muscae	Mus.
Rule*	Norma	Normae	Nor.
Octant*	Octans	Octantis	Oct.
Serpent-Bearer	Ophiuchus	Ophiuchi	Oph.
Giant-Hunter	Orion	Orionis	Ori.
Peacock*	Pavo	Pavonis	Pav.
Winged Horse	Pegasus	Pegasi	Peg.
Rescuer	Perseus	Persei	Per.
Phoenix*	Phoenix	Phoenicis	Phe.
Painter's Easel*	Pictor	Pictoris	Pic.
Fishes	Pisces	Piscium	Psc.
Southern Fish	Piscis Australis	Piscis Australis	PsA
Poop* (of Argo)	Puppis	Puppis	Pup.
Net*	*Reticulum*	*Reticuli*	Ret.
Arrow	Sagitta	Sagittae	Sge
Archer	Sagittarius	Sagittarii	Sgr.
Scorpion	Scorpius	Scorpii	Sco.
Sculptor's Workshop	Sculptor	Sculptoris	Scl.
Serpent	Serpens	Serpentis	Ser.
Sextant*	Sextans	Sextantis	Sex.
Bull	Taurus	Tauri	Tau.
Telescope*	Telescopium	Telescopii	Tel.
Toucan*	Tucana	Toucanis	Tuc.
Triangle	Triangulum	Trianguli	Tri.
Triangle (South)*	Triangulum Aust.	Trianguli Aust.	TrA.
Bear	Ursa Major	Ursae Majoris	UMa
Lesser Bear	Ursa Minor	Ursae Minoris	UMi.
Sails* (of Argo)	Vela	Velorum	Vel.
Virgin	Virgo	Virginis	Vir.
Flying Fish*	Volans	Volantis	Vol.
Fox*	Vulpecula	Vulpeculae	Vul.
Sobieski's Shield*	Scutum Sobieski	Scuti	Sct.

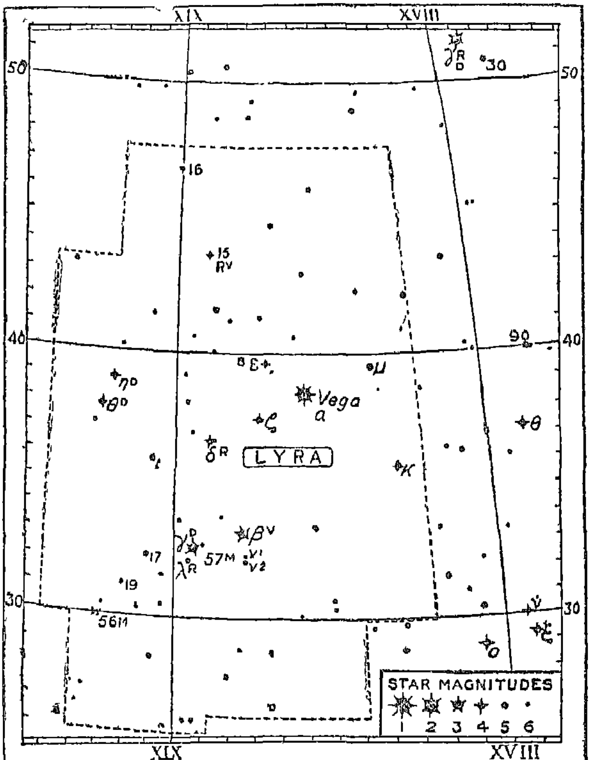
Taurus Poniatowski, Sceptrum Brandenburgium, Harpa Georgii, Globus Aethereus (Balloon), Avis Solitaria vel Noctua, Machina Electrica, Officina Tipographia, Telescopium Herschelii and Honores Frederici, insignificant groups of faint stars with ponderous titles, have been discarded by the International Astronomical Union.

which the individual stars are indistinguishable. The total number has been estimated at fifty to a hundred thousand millions

The stars are grouped by astronomers in certain constellations of which there are 88 now in general use; 48 have continued from the time of Ptolemy, including the Zodiac and the larger constellations containing bright stars visible from the northern hemisphere. Most of these date from early Chaldean times and were placed in the sky by the astronomer-priests of the Euphrates valley, for it appears evident that they were not Egyptian, Hindu or Chinese in their origin, because there are neither elephant, crocodile, tiger hippopotamus, nor cat among the numerous animals represented—some of which creatures would have doubtless been introduced had the constellations originated in any of those countries Nevertheless, there were Egyptian, Greek and Roman changes at a later date Deities famous in Greek and Egyptian mythology were introduced, and names have in many cases been Latinized, as, for instance, Hercules, Leo, Virgo Those Chaldean constellations originally typified the annual succession of ordinary events in the lives of those ancient peoples—events which were believed to be presided over by their sun-god and moon-god, whose position relative to the various groups of stars signified the seedtime, harvesting, hunting period, the rainy season, floodtime, midwinter, midsummer, and the like. The story of the Flood has also been traced in the arrangement of some of the constellations, while the Argonautic Expedition of the ancient Greeks was undoubtedly thus symbolized. In addition to these ancient groups there are about 40 constellations, invented since 1600, chiefly by Hevelius and Bayer, to fill in gaps between the older constellations and also to include the stars surrounding the south celestial pole. Most of these added constellations are insignificant; while some superfluous objects conceived to honour modern potentates, such as the "Sceptre of Brandenburg," have been discarded

Star Maps. The boundaries of the constellations originally followed irregular curves, in some cases vaguely suggesting the object represented In 1930 the International Astronomical Union adopted a plan in which the boundaries follow the lines of right ascension and declination corresponding to terrestrial longitude and latitude; the resulting angular arrangement suggests the boundaries of many American states. The student should acquire a star-atlas in order to become acquainted with

the position of the thousands of objects visible in the celestial dome. The stars are presented according to magnitudes with either their proper names, Greek alphabetical designation, that of Roman numerals or some famous catalogue nomenclature, together with other abbreviated information, such as V for



TYPICAL STAR-MAP. The perpendicular lines are those of right ascension, divided into hours. The horizontal lines are those of declination, divided into degrees. The dotted lines indicate the constellation of Lyra.

variable star, R for red, while Novae or new stars, star-clusters, and nebulae are also indicated.

The name of the constellation follows the Greek letter or Roman numeral, as β Lyrae, ζ Virginis, 81 Ursae Majoris or 26 Geminorum. The genitive case is always used. The list in pages

106-107 gives (1) the English name of the constellation; (2) its Latin or Greek equivalent; (3) the genitive case in which each is expressed; (4) the abbreviated form in which each constellation is now usually written.

About 140 of the brighter stars possess names; these are of great antiquity, usually Greek, Latin, or Arabic. Only about 60 are in general use, the technical nomenclature according to the letters of the Greek alphabet being preferred, particularly since they give some impression of the relative brightness of the brighter stars in a constellation, α usually being brighter than β, and so on until ω is reached, when the Roman numerals are resorted to. The stars are then much fainter and approaching the limit of naked eye visibility.

The brighter stars will, therefore, have two titles, as, for example, Sirius, which is also α Canis Majoris or, as it would be written, α CMa. Castor is also α Geminorum, Pollux is also β Geminorum, otherwise α Gem. and β Gem. But in this particular instance β is brighter than α, possibly owing to a change of relative brilliance in the course of centuries since Bayer, in 1603, first instituted this method of designating noteworthy stars.

LESSON 27

How Far Distant Are the Stars?

(See plate 29)

THE visible stars are classified according to their apparent brightness in a series of magnitudes which have no relation to their real, or, as it is called, *absolute* magnitude. Thus a faint star of the fifth magnitude may actually be larger and brighter than one of the first magnitude, its apparent faintness being due to its much greater distance The apparent magnitudes visible to the naked eye range from first down to sixth. The latter are the faintest to be perceived on a clear, dark night, in the absence of any artificial aid. Each magnitude is about 2½ times brighter than the next. This *light ratio*, precisely calculated to be 2·512 times that of the magnitude below it, shows that a difference of five magnitudes represents a ratio of brightness of about 100 to 1. Below the sixth are the telescopic magnitudes; these now extend down to the 20th magnitude for stars observed visually and 21st for stars perceptible photographically.

Visual magnitudes, as distinct from photographic magnitudes, are based on the above *light-ratio* scale, and the extent to which a star's light is below either of the standard magnitudes is indicated by decimal—as, for instance, Antares, which is 1·22, or a little more than one-fifth, below the standard first magnitude. On the other hand, there are a few stars brighter than this standard; they are measured from zero, as, for example, Capella, which is 0·21 magnitude or just over four-fifths brighter than the standard first. Then, again, there are two stars brighter than even zero; these are Sirius and Canopus, which have a negative magnitude, rendered thus: Sirius −1·58 and Canopus −0·86, the figures being preceded by the minus sign. On this scale, the sun is a star of magnitude −26·7, while the moon's magnitude is −11·2.

Photographic methods of determining magnitudes have produced a somewhat different scale from the visual. Stars of different brightness produce dots of different size on the photographic plates, and this is used to determine the magnitude. Moreover, by lengthening the exposure, the light of very faint stars, invisible to the eye through even the highest powers of the telescope, becomes imprinted on the photographic plate as a result of the accumulation of the star's light. Again, since the photographic plate is relatively more sensitive to the blue end of the spectrum, if a blue star and a red star of equal visual magnitude be photographed, the blue will appear much brighter on the plate. The difference of the photographic, minus the visual, is known as the *colour-index*. By using a yellow filter with isochromatic plates, a magnitude scale corresponding very closely with the visual has been obtained; such magnitudes are called *photo-visual*. By means of this method of photography, visual magnitudes may be obtained of the millions of fainter stars.

The table in p. 112 gives the number of stars between each standard magnitude; those below sixth magnitude are according to the estimates of Seares and van Rhijn. The brighter magnitudes are subject to different estimates owing to the number of stars whose brightness varies, while the number of the telescopic stars is calculated from counts over certain areas.

It is usual to include in a given magnitude all stars with ·5 above or below the standard magnitude, as indicated in the table. There are, in addition to this estimated number of visible stars, immense numbers more, which will be revealed as higher powers of the telescope are effected. Estimates of a 21st magnitude but

dimly indicated photographically nearly double the number of the 20th. More still only reveal their existence collectively as a dim luminosity in the remoter parts of the galaxy. It has, therefore, been further roughly estimated by Seares and van Rhijn from several considerations that the total number of stars reaches the colossal figure of about 30,000,000,000.

Standard Magnitude	Number of stars calculated according to: Photographic magnitude	Visual magnitude
Above 1·5	20	20
From 1·5 to 2·5	38	41
2·5 to 3·5	111	138
3·5 to 4·5	300	454
4·5 to 5·5	950	1,480
5·5 to 6·5	3,150	4,750
6·5 to 7·5	8,200	14,300
7·5 to 8·5	22,800	41,000
8·5 to 9·5	62,000	117,000
9·5 to 10·5	166,000	324,000
10·5 to 11·5	431,000	870,000
11·5 to 12·5	1,100,000	2,270,000
12·5 to 13·5	2,720,000	5,700,000
13·5 to 14·5	6,500,000	13,800,000
14·5 to 15·5	15,000,000	32,000,000
15·5 to 16·5	33,000,000	71,000,000
16·5 to 17·5	70,000,000	150,000,000
17·5 to 18·5	143,000,000	296,000,000
18·5 to 19·5	275,000,000	560,000,000
19·5 to 20·5	505,000,000	1,000,000,000

The tremendous distances of the stars afford the next most astounding fact. The remoteness of even the nearest is arrived at by means of their *annual parallax*; that is, the apparent position of the nearest stars changes relatively to that of the more distant ones in consequence of the earth's annual change of position in its orbit round the sun. The difference in the star's apparent position is very slight, and depends upon the side of the earth's orbit from which we are looking. This represents an annual translation of about 186,000,000 miles, say, between mid-summer

and mid-winter, and produces a different perspective in the apparent relation of one star to another ; the difference is much less for the more distant stars, until a point is reached at which any apparent change is imperceptible by means at present at our disposal. The limit at present is ·001 of a second of arc. Thus only a limited number of stars can have their distance measured by this method, in spite of the immense length of the base-line subtended by the earth's orbit.

The annual parallax of a star is, therefore, equal to the angle which would be subtended at that star by the diameter of the earth's orbit ; but there is no star in whose case this parallax would amount to as much as a single second of arc. The great difficulty of measuring quantities of this nature, and which also are much involved, is obvious. The most delicate instruments and refined handling are necessary, together with numerous most accurately measured observations, the parallax shift having to be disentangled from the star's own *proper motion* through space.

Units of Measurement. Stellar distances are so gigantic that we are forced to represent them in terms of some different unit from that ordinarily used. Miles become meaningless, for the *nearest star is about 270,000 times farther away than the earth is* from the sun, which means that it is about 25,110,000,000,000 miles away. On the other hand, suppose we take the sun's distance, which is the *astronomical unit* of 93 million miles, and represent this by a foot, the sun would then be, in proportion, a tiny sphere $\frac{1}{8}$ of an inch in diameter, the earth a scarcely perceptible speck of dust, while the nearest star on this scale would be about fifty miles away.

To represent the distance of a star in terms of parallax, this would have always to be expressed in small fractions of a second, which would vary inversely as to the parallax. This inconvenient method has been overcome by the institution of the *parsec.* This represents the distance at which the diameter of the earth's orbit would subtend an angle of one second of arc, expressed as 1″. Thus the *par*allax and one *sec*ond make the standard *parsec,* which is 206,265 times the sun's distance, or astronomical units, and represents about 20,000,000,000,000 miles. A *kiloparsec* represents 1000 parsecs and a *megaparsec* a million parsecs.

An older and more popular unit of measurement is the *light-year,* which represents the distance light travels in vacuo at

186,271 miles per second, according to the accepted standard of Michelson. Light travels from the sun in a little over 8 minutes or 499 seconds; it travels 63,290 times the sun's distance (i.e. astronomical units) in a year; thus we get a most convenient standard easily grasped; hence its extensive use. There are 3·26 light-years in a parsec, or, more precisely, a light-year is 0·3069 of a parsec. Another rarely used unit is the *sirio-meter*, representing a million astronomical units.

From the above we see that if a star were at a distance that caused its apparent annual shift or parallax to amount to 1″, or one parsec, this would equal 3·26 light-years; so to find the distance of any star from its parallax this simple formula may be used: $d = \frac{3 \cdot 26}{p}$ where d is the distance in light-years and p is the parallax in seconds.

The diagrams given in plate 29 show, in exaggerated form for simplicity, how the parallax is obtained. Observations were originally taken visually, and it was thus that Bessel in 1838 measured for the first time the distance of a star. This was 61 Cygni, a small double star which, from its relatively rapid *proper motion*, led him to suspect that it was one of the nearest; it proved to be 10 light-years distant. Soon after Bessel's discovery Henderson, at the Cape of Good Hope observatory, found that the bright star Alpha Centauri was (as was thought then) at 3 light-years' distance; it is now known to be about 4¼ light-years.

The photographic method of obtaining parallaxes was introduced by Professor Pritchard of Oxford in 1886, and, instead of laborious observations, photographic plates were exposed when the earth was at opposite sides of its orbit. The observations have to be made at the same hour-angle to avoid varying effects of refraction and atmospheric dispersion. Over a dozen plates are now taken, the comparison stars having to be measured too for proper motion and in case any of them are near enough to have an appreciable parallax.

Stars showing a parallax of only ·005 of a second, which represents about 650 light-years, can now be measured with a fair degree of accuracy, while less sure measurements may be taken down to ·001″, which represents about 1,000 light-years.

Our Course in Astronomy is continued in Volume 5.

BIOLOGY

LESSON 23

Early Stages in Plant Evolution

In Lesson 12 (Volume 2, page 72) we noted that the possession of chlorophyll was one of the features which distinguish plant from animal, but in the microscopic world the distinction between plant and animal is not always clear. The early forms of life seem to have been indefinite in this respect; they were neither clearly animal nor clearly vegetable, but, if we may judge from low forms of life of the present day, primeval organisms showed some features of both worlds. Thus the mat of thin white threads that covers a piece of stale bread—mould as it is called—belongs to the plant world, although it has no chlorophyll, nor does it feed in a plant-like way. It obtains its food by dissolving organic matter in the bread and then absorbing the resultant nutritious fluid. In spite of this octopus-like method of feeding, mould reproduces itself as a true vegetable should. A little spore case develops on the top of a thread and shoots out hundreds of tiny spores into the air, ready to settle on any dead organic matter and grow into another mat of mould. We must, therefore, include this fungus in the plant world, just as we included the *Sphaerella* (*see* Lesson 3, Volume 1, page 83) and other flagellates, although they show animal-like activity.

The earliest plants grew in the sea and, perhaps, rivers; they were one-celled. They sometimes formed groups or colonies of single cells, such as the *Collozoum*; again, cell would join on to cell and form a long ribbon, such as the common seaweed. In this way the seaweeds were able to float near the surface of the water, each cell receiving the maximum of sunlight, by which the chlorophyll could utilize the nitrates, etc., dissolved in the surrounding water. Thus, to-day, *Laminaria*, a species of seaweed which grows in the tidal waters of the Pacific, has long leathery ribbons of over one hundred feet.

First Land Plants. Early in the world's history, owing perhaps to the rising of the sea bed, some marine plants found themselves in shallow water and began to adapt themselves to life on land. No longer able to obtain nourishment from the water, they began to seek it from the mud. The big seaweeds had supported their

long filaments by a stem, which clung to the rocks by means of a "hold fast" and the new land plants drove their stems into the mud in order to support the stem

The stem itself had to be made of stouter stuff and some early plants threw up a shoot from their underground stems to a height of twenty inches The shoot carried no leaves but terminated in a spore capsule, like that borne by bread moulds moss and ferns of to day The spore capsules of *Hornea* one of the earliest land plants, were merely modified branches, and exemplify the beginnings of structures specially adapted to carrying the non-sexual reproductive cells Some of the structural features of the plant are distinctly akin to those of seaweeds These early leafless land plants bore on the stem breathing pores or stomata, by which the plant obtained carbon from the air

Another species (*Asteroxylon*) of primal land plants bore scales on the stem, which developed into spiny leaves on the higher shoots There can be seen traces of veins running through these leaves, and this species, although found in the same geological strata, shows a great advance on *Hornea*

The main thread, however, in the story of plant evolution is the chain of steps by which plants at last managed to fertilize their seed without the intervention of water The water plants *shed their reproductive cells into the surrounding water* The two different processes of reproduction practised by the one-celled water vegetable, *Sphaerella*, are described in Lesson 4, Volume 1, page 87 The single cell of *Sphaerella* usually divides and becomes four new individuals This is the non-sexual method of generation At times, however, the mother cell divides into thirty-two smaller individuals which swim, by means of flagella towards each other, and pairs of them fuse to form another individual This may be considered as a primitive form of sexual reproduction

Reproduction by Spores. A similar reproductive process is practised by the plants which were the earliest land dwellers They produced spores, just as moulds, mosses and ferns do to-day The spore is a tiny piece of living tissue which reproduces without fertilization The fern spore germinates in damp ground, it does not produce a fern, but a small plate of green tissue, shaped something like a miniature bicycle saddle, which is called a *prothallus* This tissue develops, on its under side, male and female gametes The former are active sperms which actually

swim, by means of flagella, through the drops of moisture on the underside of the prothallus towards the female gamete. The female gamete is a single cell contained in a sac-like structure. Fertilization takes place and a new fern plant is the result. This alternation of generations—(a) non-sexual spore-bearing fern, (b) gamete-bearing prothallus—needs the intervention of water to enable the male sperm to swim towards the female egg. Thus the early plants had to live in bogs and on the riverside, just as moss and ferns keep to moist places to-day.

Horse-tails, ferns and club-mosses, types of some of the earliest known plants, all produced spores and prothalli. The horse-tails, unlike the true moss, had large vascular stems (i.e. stems containing pipe cells for the conveyance of water and food), and formed mighty trees in the Coal Age. They produced spores all alike, which, however, germinated into a male prothallus if they fell on poor soil, but formed a female prothallus if the soil were rich. One species of club-mosses, the Lycopods of today, shed an immense number of spores (the lycopodium powder used in fireworks). These spores are all of one kind, but many species of fossil Lycopods bore small male spores (microspores) and large female megaspores. The female megaspore developed a prothallus within the enclosing skin, and was then shed. The microspores were also shed, and, if water were present, the sperms, attracted by the secretion of malic acid in the female prothallus, swam towards it and fertilization resulted. This process, it will be noted, is a step nearer the production of a true seed, and is not so dependent on the presence of water for the formation of the female prothallus. An ancient species of giant Lycopod (*Lepidodendron*) is described in a later Lesson. These plants (ferns, horse-tails, Lycopods), which produce spores and prothalli, are grouped as Cryptogams (hidden seeds).

Another very important group of ancient plants, Pteridosperms or seed-ferns, was for a time confused with the cryptogamous true fern, because the impressions of its foliage found in the Coal Measures were very like those of the true fern. Unlike the true ferns, however, the seed-ferns retained the megaspore on the leaf and the seed formed inside a seed-coat, which had a small opening. The male spores, or, as we should now call them, pollen grains, were borne by wind to this opening. Through drops of water, which were drawn up through little pipes into this seed chamber, the spermatozoa swam to fertilize the seed. In the

highest type of Gymnosperms or naked-seeded plants—the Conifers—the male prothallus is reduced to a pollen-tube (see Lesson 13, Volume 2, page 75), and the sperm has, accordingly, no need to swim. Plant life has thus, at last, abandoned this characteristic feature of the animal world—swimming spermatozoa—and is now adapted for life in dry situations.

The Angiosperms (sheltered seed plants) have evolved a still further stage. Their method of fertilization is described in Lesson 13. The male spore leaf has become a stamen, and the female spore leaf forms the carpel, which shelters the seed and embryo. Hence their success. Today there are 100,000 species of Angiosperms, nearly 2,500 species of Gymnosperms (pines, firs, etc.) and about 3,000 species of Cryptogams (ferns).

An excellent diagram of the evolution of seed and flower is given in "The Science of Life," Wells, Huxley and Wells (Book V, p. 479). Dr. Marie Stopes, in "Ancient Plants" (Blackie), describes the various types of plant stems.

LESSON 24

Signal Steps in Animal Evolution

The stages by which new and more complex structures arose and by which existing structures were gradually adapted to their environment are more clearly indicated in the animal than in the vegetable kingdom. There are no geological traces of the earliest forms of life, but it may be assumed that life started as some microscopic or ultra-microscopic speck of protoplasm. It must have been an enormous evolutionary step from this earliest form to the unit cell possessing a single nucleus with chromosomes and genes, but it is a step of which we have no record. The next step was that taken by the one-celled animal to overcome the limitations imposed by its small body; this step resulted in the formation of a colony of one-celled creatures; the united cilia of a colony of cells would draw a large volume of food to each individual cell. A next step would be a division of labour. The outer layer of cells would become protective, the inner would be concerned with the assimilation of food; while, as in many existing colonies of single cells, the function of reproduction would be limited to certain cells only of the colony.

Thus the gap between Protozoa and Metazoa—one-celled and many-celled animals—would be bridged.

Division of Labour. A two-layered structure of cells, outer and inner, is the usual form in the creatures known as *Coelentera*, the cells being specialized into stinging cells, digestive and muscle cells, and nerve cells The next step in complexity of structure is the development of a three-layered body. The outside layer of cells (or ectoderm) produces the nerve system and outer skin; the middle layer (mesoderm) forms muscle, gonads, blood system, and, in mammals, kidneys and skeleton ; the inside layer of cells (endoderm) becomes the digestive tube.

This three-layered construction is found in a rudimentary form in the worm phyla, and is the common type of structure in the higher groups. The flatworms have no circulatory or respiratory system ; their bodies must, therefore, be flat and thin, so that, as in a tree leaf, all the tissues receive oxygen easily from the surface. The gut is branched to all parts of the body to facilitate the distribution of food, but, instead of the diffuse nerve net of the Coelenterates, the flatworms possess a central nervous system with head-ganglia.

In other groups of worms we find the beginnings of a coelom (a space developed from the mesoderm, or middle layer of cells, to hold the lungs, heart, intestines, etc.). The worm group is further distinguished by red blood, an anus or posterior opening of the digestive tube, and segmented body—features common to the higher phyla, and which point to the common ancestry of worms and higher groups.

The nerve system is further advanced in the arthropods, in the higher types of which the nerve ganglia are concentrated near the head.

Insect Development. A land life demanded many innovations in structure. For example, the insects aerated their bodies by a network of air tubes, or tracheae, and another new structure was the insects' wings. The flying vertebrates—the birds, bats, flying fish and flying lizards—have all made use of existing limbs and modified them for flight, but the arthropod flyers—the insects—have two pairs of new (wing) structures growing from the thorax.

It is on land, too, that instinct reaches its highest development. The social instincts of insects, as displayed in an ant hill or bee hive, show evolutionary advance in the direction of regulating reproduction beyond any stage reached either by the instinct or

reason in other phyla Thus many ants breed soldiers, nurses and general workers which are sexless and concentrate entirely on their work Insects were among the earliest land dwellers and the powers of organization which they have developed should have made them today a dominant form of life They have, however, been handicapped by their skeleton, which is outside and limits the growth of the body Insects with a two-foot wing span existed in the Carboniferous Age, but this is the maximum breadth to which they have attained Some insects e g the cockroaches and grasshoppers moult" their body covering and the lining of the stomach several times during growth but the more specialized insects, such as butterflies, adjust their exo-skeleton in one moult They devote one stage (the larval) of their life entirely to eating and growing The second stage is a resting stage, during which the larval organs are broken down by the white blood cells while the cells which form wings, antennae, etc, grow until there suddenly bursts from the inert pupa the lovely, graceful, fully developed adult

Although this method reduces the moulting to one operation only, it involves no less than the frequent moultings, a period when the skeleton is immature and soft, so that an animal of any bulk would not only be defenceless but would collapse Hence insects—and arthropods generally—are limited in bulk

A very important step up the evolutionary ladder was taken by the reptiles in providing the special membranes in the egg—(a) the allantois, or embryo's breathing organ, and (b) the amnion (a protective water cushion), which enabled the reptiles to live and reproduce on dry land

The Mammals. A further development of the allantois—the placenta—is found in mammals It has been described in Lesson 22 (Vol 3, p 130) The developed state in which, owing to the placenta, the young mammals are born, their warm blood and the high development of intellect, make the mammals more independent of their environment than other vertebrates The higher mammals, especially those that took to tree life, had to depend for success on their power of vision and delicacy of touch, the correct estimation of distance from branch to branch, and the examination, by feeling and testing, of the strength of dead wood, and of the edibility of strange fruit, demanding highly developed visual and tactile organs All this would lead to increased manual dexterity and greater brain development.

Such creatures would rely on reason rather than, like the insects, on "blind" instinct, and would tend to develop the sense of sight rather than that of smell, which is the main pilot of ground mammals.

The tactile, visual and association centres of the brain show a continual increase in size if we compare lemurs with monkeys, monkeys with apes, and apes with Man, while the centres connected with smell show a relative decrease.

Dominance of Man. Of the mammals, Man, owing to his large brain, is already dominant, although, biologically, he is a new-comer. His immediate ancestors were perhaps forced to the ground owing to the failure of tree growth. The dangers and necessities of his new environment would need his dawning reason, rather than his old instincts, to combat and relieve them. Each new structural feature has given its possessor a wider environment and greater experience, and Man, with his complex brain and nerve structure, has achieved consciousness of his experience and of his power to extend it.

The following table gives some of the main steps by which life has been raised from a lower to a higher level:

Body Structure.	Groups.
1. No nucleus	Bacteria.
2. Single Cell with nucleus	Protozoa.
3. Colonies of unit cells, e.g.	Volvox
4. Two layers of cells	Sponges.
5. Mouth and nerve net	Coelenterates.
6. Nerve ring	Jelly-fish.
7. Three-layered body and excretory system	Flatworms.
8. Rudiments of blood system, Anus	Roundworms.
9. Coelom, heart, gills	Echinoderms. Earthworms. Leeches. Tunicates.
10. Head. Beginning of brain, sense organs	Crustacea.
11. Development of instinct .. .. ,, ,, trachea	Spiders. Bees. Wasps. Ants.
,, ,, amnion and allantois	Reptiles

	Elaboration of heart and lungs, warm blood backbone, care of young Memory	Birds and Mammals
12	Intelligence	Monkeys and Apes.
	Use of hands	
	Reliance on sight rather than on sense of smell	
13	Convoluted brain	Man.
	Reason Speech	
	Use of tools	

Degeneration. It must be remembered, however, that all adaptation has not been in the direction of progress Nearly all plants and animals that have adapted themselves to a parasitic life have degenerated in the process The crustacean, *Sacculina,* for example, begins its life as an active larval crustacean It has a chitinous skeleton, jointed limbs, and eyes and a heart like those of young lobsters and crabs After moulting however, it fastens itself to some adult crab, on which it settles for life It develops root-like organs, which penetrate to all parts of the body of its host, loses eyes and limbs, and degenerates into a bag of eggs nourished from the blood of its victim The barnacle and sea squirt afford examples of degeneracy due to abandoning an active mode of life for a passive and sessile existence

The following additional reading is recommended "Origin and Evolution of Life," Osborn (Bell), "Animal Biology," Haldane and Huxley (O U P), "Science of Life," Book II, Wells, Huxley, and Wells.

LESSON 25

Plant Evolution in Geological Time

In studying the evolution of plant or animal life the reader is at once confronted with the difficulty of appreciating geological time, and of realizing the relative magnitudes of the vast eras into which the existence of the earth has been divided To enable the reader to follow this Lesson, these eras may be thus tabulated, beginning with the most recent :

PLANT EVOLUTION IN GEOLOGIC TIME

ERAS	PERIODS	LIFE FORMS
Cainozoic	Recent	
	Pleistocene	Man
	Pliocene	
	Miocene	Age of Mammals
	Oligocene	
	Eocene	
Mesozoic	*Cretaceous*	*Angiosperms*
	Jurassic	Birds (and Mammals)
	Triassic	Cycads and Bennettitales
Palaeozoic	Permian	Pteridosperms
	Carboniferous	Reptiles, Insects
	Devonian	Amphibians
	Silurian	Cryptogams
	Ordovician	Fishes
	Cambrian	Invertebrates
Primeval or Eozoic	Proterozoic	Few fossil traces of life Algae
	Archaeozoic	Possibly without life

Eozoic Age. Very little evidence of plant life has been found in rocks of the Eozoic era. This is not surprising, since violent volcanic upheavals have torn, contorted, and tilted these early sedimentary rocks. Moreover, the plant life of this era, if plant life there were, must have been without any woody or cellulose structure, so that no certain traces of vegetable life have been found in Archaeozoic rocks and only traces of Algae in Proterozoic strata. Beds of graphite (carbon) are found in Archaeozoic rocks, however, which probably are composed of the remains of lowly marine plants.

About the beginning of the Palaeozoic period plants began to take to the land. The seaweeds of the time derived their food from the surrounding water, as they do today. The early land plants must have clung to the seashore and river mouths, so that water would be brought to them by every high tide. Moss has the same dependence on water and clings to damp nooks and crannies at the present day. In such positions plant life developed true roots, and began to obtain its water, nitrogen

and mineral salts from the muddy silt deposited at the river mouth At the same time it would have to depend on the air for carbon dioxide, and green leaves must be grown, so that these food constituents could be exposed to sunlight To bring these constituents together and to form a support for the leaves, a stiff woody stem would need to be developed All this was a process taking place over millions of years

Palaeozoic Era. Discoveries in the rocks near Rhynie, in Aberdeenshire, furnish records of some of the earliest known plants (Hornea and Rhynia) Rhynia grew from 7 to 20 inches in height, and was unlike any plant of today It had no leaves it was rootless, and its underground stems sent up shoots which bore no true seeds, but spore capsules only Hornea had tuber like swellings on its underground stems, and the structure of the spore capsules was different, but otherwise its appearance was similar to that of Rhynia Both plants grew in bogs, a third plant which grew in the same bog had leaves only on the lower part of the stem These slender rush-like plants were the sole relief to the bare rocky landscape of the early Devonian period of three hundred million years ago Only in the pools and the sea were there signs of animal life

Fossils of large trees are found in rocks which were laid down at the end of the Devonian period and at the beginning of the Carboniferous period These trees are placed in the five following groups (1) true ferns, (2) cordaites—a group which is related to the conifers of today (3) the club-moss group, which in the late Devonian period and Carboniferous period grew into trees of 90 feet in height, although their representatives of today are lowly plants of only one to two feet in height, (4) calamites, or horsetails, which, represented today by a single humble species (*Equisetum*), also grew into trees, their stems, however, like those of the club-mosses, were of primitive structure, and were unable to carry large spreading branches, (5) pteridosperms, or seed ferns There are no living members of this group today, but in the Carboniferous period it was a dominant type of vegetation The leaves of this group were fern-like, but, unlike the true ferns, the pteridosperms bore seeds which were attached to the ordinary leaf of the plant, and there were no cones or flowers such as are borne by the higher plants In virtue of the structure of the stem and reproductive organs this group forms a connecting link between ferns and higher plants

The Coal Age. Some coal was formed both before and after the Carboniferous period, but it was in this period, when the lycopods or club-mosses and the horsetails flourished at their best, that the bulk of the coal deposits was laid down. These two groups, together with the pteridosperms, formed the lush forests of the time. In the Victoria Park, Glasgow, are preserved some of the huge fossil stems of the lepidodendron, a genus of lycopods. Their underground structures are unlike the roots of the trees of today, the leafy stem at the base dividing into four main divisions or "roots," each of which subdivided into two, and these again into two, and so on. The surface of these big roots was covered with rootlets, which appear to have drawn nourishment from the surrounding decaying vegetable matter, for these rootlets are found to have pierced to the heart of other fossilized woody stems. The climate of the Carboniferous period must have been a kindly one for vegetation. The comparative absence of annular rings in the petrified stems suggests only small variations between winter and summer temperature.

During the many million years which make up the Carboniferous period, these forest lands slowly sank, were inundated, and their vegetation drowned and silted over. In places the surface rose again, and a new forest grew over the site of the earlier one, and so on, till we have coal seams of many hundreds of feet in thickness.

The Ice Cap. At the end of the Carboniferous period a large part of the southern hemisphere became covered with ice, and the climate of the northern world became dryer. Fossils of this period (Permian) show that in the southern hemisphere a shrub-like species of pteridosperm (known as *Glossopteris*) flourished, which seems to have been able to grow in a cold and dry climate.

Mesozoic Era. The two characteristic groups of fossil plants of this era are the *Cycads* and *Bennettitales*. The former had a thick stem surmounted by a crown of palm-like leaves, and produced cones something like those which grow on the pine trees of today; but the *Bennettitales* had reproductive organs which are thought to be half-way between a cone and a flower. It was not until the Cretaceous period that flowers, as we know them today, were fully evolved, and, as the partnership between flowers and insects became more specialized, so the flower-bearing plants (angiosperms, bearing seeds in carpels) became the dominant species of vegetation (*see* Lesson 24, page 118).

The method of fructification practised up to, and including, the Carboniferous period was that of separate spore and prothallus and active swimming spermatozoa. Ferns, liver worts and mosses still use this ancient mode of fertilization but from the Cretaceous period, and onward, the higher plants (monocotyledons—one-lobed seed, e.g. grasses and palms, and dicotyledons—two-lobed seed, e.g. trees, peas and beans) have converted the male spore leaf into a stamen, the female spore leaf has become a carpel or ovary, and the sperm floats down to the ovum in a thread of semi-liquid protoplasm, which grows from the pollen grain to the heart of the seed-bearing structure.

Plant evolution is fully dealt with in: "Plant Life Through the Ages," Seward (Cambridge University Press); "Studies in Fossil Botany," D. H. Scott.

LESSON 26

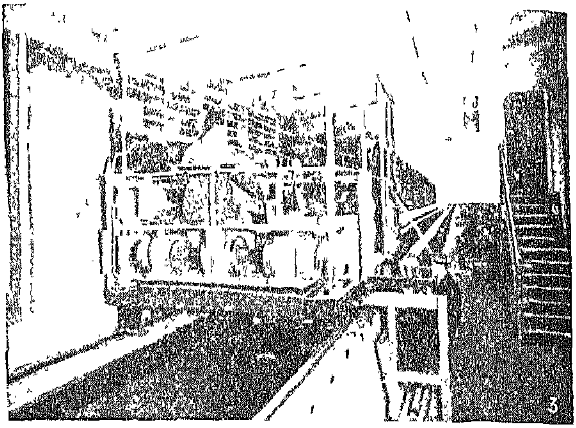
Fossil Evidence of Animal Evolution

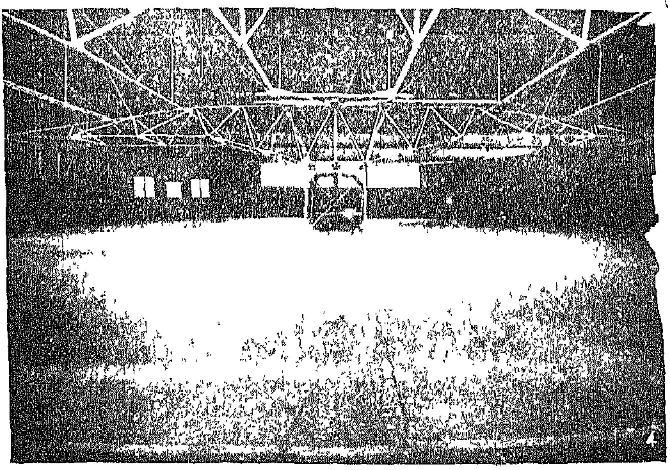
EARLY forms of life in the Eozoic period, whether animal, vegetable or partly both (*see* table of the geological epochs in the preceding Lesson), were for the most part soft-bodied, and left little trace of their existence in the rocks. Deposits of iron found in Proterozoic rocks are thought to have been precipitated by the action of bacteria, while, in the later rocks of this era, microscopic spicules of many kinds of sponges are found, and worm tunnels show the existence of worms. Geologists find a gap, representing millions of years in time, between the latest Proterozoic rocks and the rocks known as Lower Cambrian—the first of the Palaeozoic era. The reason for this gap does not here concern us but there is a reasonable presumption that life was evolving during the long interval between the late Proterozoic and early Palaeozoic eras. Thus we find in the Lower Cambrian rocks abundant evidence of life, which has already become diversified into phyla and classes. Among the fossils of the period are trilobites—primitive arthropods, something like the woodlouse of today, which later branched out into many new families, reaching their apex of diversity in the Ordovician period and becoming extinct in the Carboniferous.

TWO VICTORIAN PAINTERS Left 'Love and Death,' one of the allegorical pictures of George Frederick Watts (1817–1904) also famous for his portraits of the intellectual leaders of his day Above portrait of Mrs Leonard Collmann by Alfred Stevens (1817–1875) painter draughtsman and sculptor of genius (*see* Plate 20)

ART AND ARCHITECTURE 1)

National Gallery Millbank





AIRCRAFT RESEARCH APPLIANCES. **Fig. 3.** Water tank for testing the hul
and floats of seaplanes. **Fig. 4.** Whirling arm for the study of circular flight
this appliance is at the National Physical Laboratory, Teddington. The model
is suspended at one end of the arm, the speed of which can be regulated.
AERONAUTICS 24

Courtesy of The Royal Aeronautical Society

The phylum *Echinoderma* is represented by fossil sea lilies (crinoids), which fasten themselves by a stalk to the sea floor, feeding themselves by means of cilia ; they constitute the only class of echinoderms that feeds in this way today. In the Middle Cambrian rocks there are traces of sea cucumbers ; and the higher forms of this phylum—starfish, brittle stars and sea urchins—appear in the Ordovician rocks. The soft-bodied worms are also present as burrowing worms, bristle and arrow worms. In addition, there were lamp shells (*Brachiopoda*)—a species in which little revolutionary change can be detected in about 300 million years—some lower members of *Mollusca*, but no fish or land animals.

The First Vertebrates In the Ordovician rocks fish—the first vertebrates—appear, and by the end of the Devonian period some vertebrates had begun to crawl out of the water, or were forced by drought to live an amphibious life. Their eggs are so small and unprotected from influences which would dry them up that they have to be laid and hatched in water ; also, the adult amphibian itself must live near moisture.

These early amphibians (such as *Branchiosaurus*, Lower Permian period) possessed legs which were fully developed for land life. Very much larger than *Branchiosaurus* were the Labyrinthodonts—bulky creatures with enormous heads and stumpy tails, but with short, weak legs which could not have lifted their bodies from the ground ; they could, therefore, have only shuffled over the mud. There is no geological record of animals having limbs which are in the transition stage between fins and legs, but a fish called the mudhopper manages to scramble out of the water today by using fins, and the first land crawlers may have travelled in a similar fashion. The moist skin, the carnivorous diet, the large number of small eggs laid by amphibians, and the development of the amphibian skeleton clearly point to a fishy ancestry, especially as, until the amphibians appeared, the bony fish were the only vertebrates in the world.

In the Silurian or Early Devonian period the arthropods left the water and learned to fly. In the Carboniferous rocks insects of an advanced type are found. There was one species, unlike any insect of today, from which the present-day locust is descended : another probably was the ancestral cockroach ; and a third (*Meganeura*) was a Palaeozoic dragon-fly with wings of two feet from tip to tip. Thus the early amphibians could find

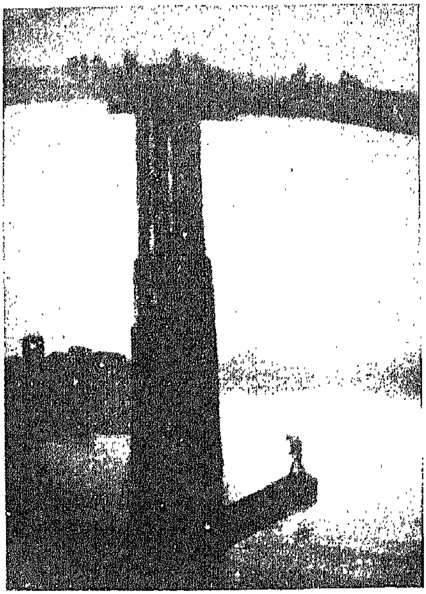
food on land, and, though, perhaps, they still lived largely in the water, they would often crawl out on a dead branch the better to snap at a passing insect, just as the mudhopper fish and the amphibious frog do today.

Appearance of Reptiles. The earliest fossils of reptiles are from Upper Carboniferous rocks in New Mexico. Just as the seed-bearing plant is more independent of water than the spore-bearing, so the reptile was superior to the amphibian. The reptile laid a large hard-shelled egg, which contained two protective membranes—the allantois and the amnion. The hard shell of the egg made it necessary that the egg should be fertilized before deposition, and thus the reptiles introduced courtship and mating to the land world. Further, the young were better protected, which meant that fewer need be produced, so that the parents could guard their offspring as present-day adders and crocodiles do. Thus maternal care became a factor in evolution. During the dry period which succeeded the Carboniferous age many species of amphibians became extinct, and the reptiles, with their tough dry skin, with their legs available for land use, and their ability to dispense with the water tadpole phase of life, became the dominant land dwellers.

In the Permian period reptiles had already branched into several species, and later, in the Mesozoic rocks, fossils are found of carnivorous aquatic, terrestial and aerial reptiles.

The ichthyosaur, an aquatic reptile of the Jurassic period, had paddles, the bones of which, although compressed for paddling, were the bones of a land animal. Other reptiles (*Rhynchocephalia*) had their front teeth curved and projecting, giving the appearance of a beak This feature is still seen in the New Zealand lizard, *Sphenodon,* which has an opening in the skull due to the vestige of a middle eye, with lens and retina, under the skin on the top of the head.

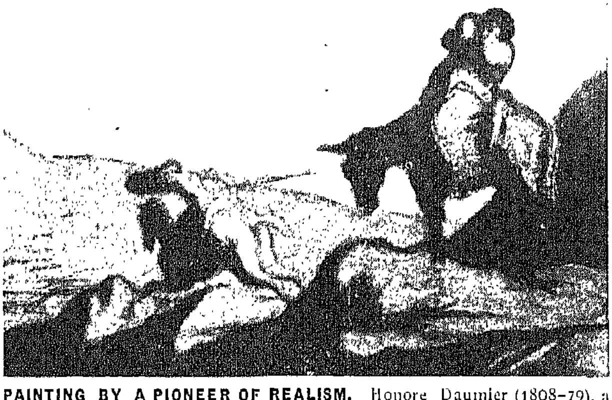
Evolution of Bulk. The dinosaurs of Triassic rocks were land reptiles, which persisted throughout the 100,000,000 years of the Mesozoic era. They branched into many orders. Some of the earliest species ran on their hind legs only, with tail outstretched as counterbalance ; others leapt in kangaroo fashion. The *Saurischia* of Jurassic and Cretaceous rocks developed such huge bulk that they were forced to revert to four-footed progression. The fossils of *Gigantosaurus* found in Africa are those of an animal weighing from thirty to forty tons. *Diplodocus,*



A WHISTLER NOCTURNE. James Abbot McNeill Whistler (1834–1903), born at Lowell, Mass., U.S.A., after studying and working in Paris, painted in England. In his series of night pieces on the Thames—one of the loveliest of which, "Old Battersea Bridge," is reproduced here — Japanese influence is seen.

ART AND ARCHITECTURE 20

National Gallery, Millbank



PAINTING BY A PIONEER OF REALISM. Honore Daumier (1808–79), a French master of the 19th century, was little appreciated in his life-time. Like the Spanish artist Goya, Daumier excelled in scathing satires and in portraying scenes from the common life of the people. Intensely dramatic, he also possessed imagination, as his picture, reproduced above, of "Don Quixote and Sancho Panza" reveals, with its tilting knight and eerie shadows.

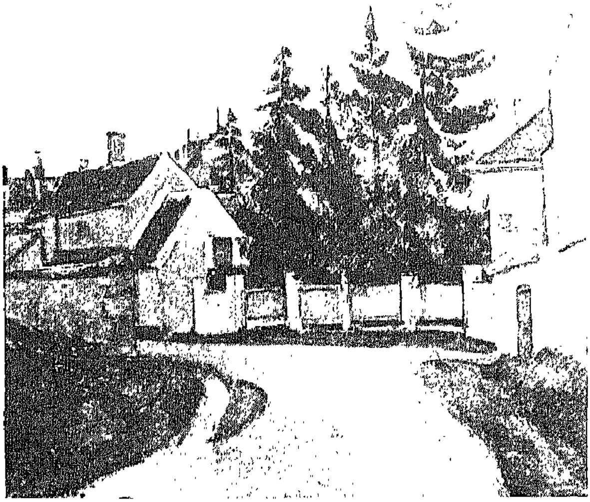
ART AND ARCHITECTURE 20

National Gallery, Millbank

EXAMPLES OF IMPRESSIONISM. Edouard Manet (1832–1883) and Pierre-Auguste Renoir (1841–1919) were two of the leaders of the French Impressionist movement. Above, Manet's "La Servante de Bocks"; right, Renoir's "Les Parapluies."

ART AND ARCHITECTURE 20

National Gallery, Millbank

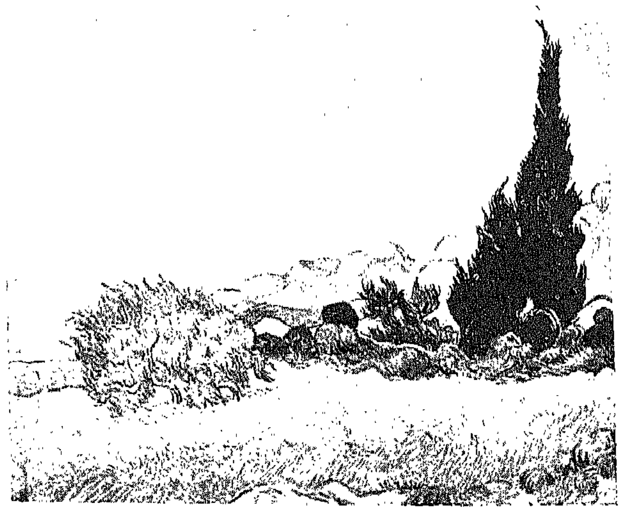


POST-IMPRESSIONISM. Top, " Road at Anvers " of Paul Cézanne (1839–1908) a work of austere beauty by a painter who has had the strongest influences on modern art. Below, " Te Rerioa," a study of life in Tahiti, by Paul Gauguin (1848-1903), whose work is characterised by magnificent colour and design.
ART AND ARCHITECTURE 21

Top photo, by permission of Alex. Reid & Lefèvre, Ltd.; bottom, Courtauld Collection

ESSAY IN DECORATIVE SIMPLICITY. This "Vase of Flowers," by Henri Matisse (b. 1869), shows the characteristic delicacy and decorative effect of his style. As leader of the Fauves he pursued flat linear design instead of compositions of "solid" form.
ART AND ARCHITECTURE 21

Syndicat de la Propriété Artistique



A NEO-IMPRESSIONIST LANDSCAPE. Vincent Van Gogh (1853–1890) associated himself with Cezanne and Gauguin. As a Post-Impressionist his concern was chiefly with pattern, as exemplified in this "Landscape with Cypress Trees." ART AND ARCHITECTURE 21

National Gallery, Millbank

another huge herbivorous reptile, had a tail forty feet in length, with which it defended itself against such enemies as *Tyrannosaurus*, an immense carnivorous reptile of the period. *Stegosaurus* (Jurassic) grew large bony plates on its back as a protection: *Triceratops* (Cretaceous) had large horns and a shield-like bony rim upon its head, while *Protoceratops*, found in Cretaceous rock in Mongolia, had a bony frill which protected the neck. The largest of the dinosaurs could hardly have supported their immense carcasses on dry land. They probably lived in marshes, lakes and rivers, so that the water relieved their legs of some of their crushing weight. Huge as they were, their brains were rudimentary. The brain of the *Stegosaurus* has been calculated at $2\frac{1}{2}$ oz., and that of the most gigantic reptiles did not exceed 2 lb. Bulk for bulk, this would give the reptiles one-thousandth of the brain weight of the normal man.

Evolution of Flight. Following the insects (arthropods), a branch of the reptiles (vertebrates) took to the air during the middle Mesozoic era. They developed from the side of the body a membranous fold of skin which was stretched along the fore limbs and extended by a greatly lengthened fifth digit. The other digits were of normal length, and provided with hooked claws for climbing, bat-like, up to a height from which to "take off." *Pterodactylus* (Upper Jurassic) had a short tail, but another species had a long, bare tail with a balancing plate at the end. These early types became extinct, and their place was taken by *Archaeopteryx* (Upper Jurassic), the earliest representative of birds. Instead of the membranes of its predecessors, *Archaeopteryx* possessed true feathers, evolved out of scales along the hinder side of the fore limbs and on either side of the lizard-like tail. This primitive bird still kept its reptilian teeth, but the first digit of the foot had become opposable, and it could perch on a bough. A fossil of this "bird" is preserved in Berlin (see plate 54).

True flying birds are rare as fossils, but a study of their anatomy shows how the forearm has been strengthened, the fingers welded, and the long tail shortened to a rump, while the reptilian jaw has become a toothless beak—a modification which has also taken place in two modern reptiles, the tortoise and turtle.

Owing to climatic changes, the age of reptiles came to an end at the close of the Mesozoic era, and the many orders of reptiles of the Triassic period have today dwindled to four.

LESSON 27

Evolution of the Horse

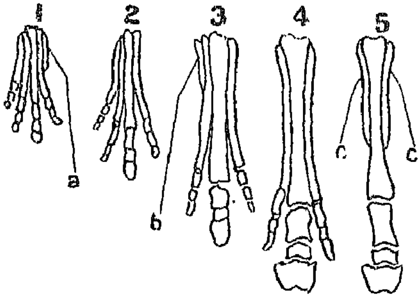
REFERENCE is made in this Lesson chiefly to the age of mammals, the Cainozoic or Tertiary era (*see* Lesson 25, page 122), which stretches back unknown millions of years from our own 20th century. This era is generally divided by geologists into the Eocene, Oligocene, Miocene, Pliocene and Pleistocene, but it is as yet impossible to say how long each period endured.

The enormous lapse of time since mammals became the dominant life-form in the Eocene period may be appreciated if it is realized that at the beginning of the Cainozoic period great mountain systems such as the Pyrenees, Alps and Himalayas were unformed, and that their sites were still level surfaces. It was not till the Miocene period that the Himalayas began to rise. The region of Colorado has slowly risen 11,000 feet since the beginning of the Oligocene period, and since then the Colorado river has carved out a gorge, the Grand Cañon, 6,500 feet deep.

The early mammals were small insectivorous or omnivorous animals with small, unspecialized teeth The teeth and jaws of small mammals found in late Mesozoic rocks show marked resemblances to those of the Australian duckmole—which, although a mammal, still retains the reptilian habit of egg laying —and to those of the Australian marsupials, a slightly less primitive mammal These fossils are of rare occurrence, which points to the fact that they were insignificant newcomers in a land dominated by the reptiles from which they had evolved. These small, slow-moving mammals had short clawed feet, which later, as different species radiated from the original stock, became feet specialized for digging, swimming, running, or for tree life.

In one group of these mammals the last phalanx of each digit was almost completely covered with horn, and from this group are descended the three orders of living ungulates, or hoofed animals, represented by the horse, the sheep, and the elephant. Some early ungulates, the *Amblypoda*, attained great size in the Eocene period, but their skull shows a very small brain, and this species became extinct at the close of the Eocene.

Ancestry of the Horse. Modern ungulates are divided into two classes—even-toed (sheep) or odd-toed (horse). During the Lower Eocene there existed, both in Europe and America, a number of primitive odd-toed ungulates (*Perissodactyla*), some species of which were the ancestors of the modern horse. The next stage in evolution was represented by the *Eohippus* and the *Hyracotherium*. These were little fox-like animals (shoulder height 11 in.), with four little hoofs, digits II, III, IV and V on the hand or fore foot (*see* diagram), and three hoofs on the hind foot; but some fossils show, in addition, two splint bones on the hind foot as vestiges of digits I and V. On both feet, digit III was the largest and strongest, and digits II and IV slightly smaller and equal, but capable of spreading outwards and supporting the small body on soft ground.



EQUINE EVOLUTION. 1. *Eohippus*: four-toed ancestor with vestige of digit I (a) (Lower Eocene); 2. Orohippus: no vestige of digit I (Middle Eocene); 3. Mesohippus: digit V (b) reduced to a splint bone (Lower Oligocene); 4. Pliohippus: digits II and IV (side toes) off the ground (Upper Miocene, Early Pliocene); 5 Equus: digits II and IV reduced to splints (c) (Upper Pliocene to present day).

The next stage is reached by *Mesohippus* (Lower Oligocene). This animal was nearly as big as a sheep (4½ hands or 18 inches at the withers). Digit V is reduced to a splint bone on the fore foot, so that both feet are now tridactyl with digit III much the best developed. This type of "horse," like its ancestors, lived in woodland and marshy districts. Its teeth were short, and were not yet elaborated for grinding, as they are in the modern horse. Mesohippus must have browsed on leaves of bushes and the soft vegetation of the river bank or marsh. This three-toed animal persisted throughout the Miocene period, and fossils of *Hypohippus*, a culminating branch of this type, found in the Lower Pliocene rocks in America, still show a spreading three-toed hoof, and teeth unsuitable for eating the tough grass of the open country. Hypohippus appears to have clung to damp forest regions, but unsuccessfully, as no further fossils are found, and it must be regarded as a divergent branch of the horse stock.

The main line of horse ancestry is represented in the Upper Miocene and Early Pliocene periods by *Pliohippus*, of which sixteen species are known Some of these species still show two small side toes with perfectly formed hoofs, which do not, however, touch the ground, while in later species these two toes have become mere side splints, as in the modern horse ; the species of Pliohippus are equipped, as regards teeth and feet, for life on drier ground or open steppe, and away from the dangerous woodland, which, by this time, was infested by large carnivores.

By the Upper Pliocene period true horses had evolved. *Plesippus*, a genus of the Late Pliocene period, shows the maximum modification of mammalian structure for speed. Every superfluous bone has gone, and those which remain are correspondingly strengthened Thus the two bones of the mammalian forearm, which were present in the earlier fossils of this series, have become welded into one bone. The animal has lost the radial action which the human forearm possesses, but the limb and muscles are specialized for rapid fore-and-aft movement. Only the last joint of the middle toe, encased in a horny development of the toe nail, touches the ground The palm has been welded into one bone—the cannon-bone—and the wrist is far above the ground and forms the " knee " of the modern horse.

Significance of Teeth Development. Corresponding gradations of skull and teeth are shown by fossils preserved in the Natural History Museum, New York. The molar and pre-molar teeth (pre-molar teeth are the molars which are preceded by milk teeth) of a modern horse are very large and, unlike our own, continue to grow for the first eight years after " cutting." Their surface consists of ridges of hard enamel, between which are cavities filled with a cement which is not quite so hard. As the horse chews hay and tough grass, the cement wears away at a slightly faster rate than the enamel and dentine. Thus the surface is always corrugated, and forms an excellent grinding face.

The teeth of Eohippus and its successors show gradual but continual advance from a low-crowned, smooth-topped type with no cement filling to the very efficient grinders of today. First, the molars become adapted for chewing, then the pre-molars of the adult follow the same pattern, although the milk teeth are smooth. Finally, in Pliohippus and from Pliohippus onwards the baby pre-molars are also elaborated.

A parallel story could be told of the evolution of other animals —camels and deer, for example—but the horse has been chosen because its fossil record, especially in North America, is remarkably complete. The story of the evolution of the horse fully corroborates that of the plant life of the Cainozoic era. From the beginning of the Miocene there was a decrease in the rainfall and a consequent shrinkage of wooded areas. Throughout the Pliocene these drier conditions were accompanied by a gradual lowering of the temperature and the formation of steppe and tundra areas, with tougher and drier food for the ungulates. Hence the need for large grinding teeth. In the open steppe-like country that was increasingly prevalent, the attack of carnivores could only be avoided by iron muscles and slim, strong limbs specialized for speed with feet adapted for hard ground.

In Lydekker's "The Horse and its Relatives" (Allen & Co.), a full description is given of existing species of the horse—kiang, onager, quagga, etc., and the probable cause of the extinction of early South American horses is discussed. Swinnerton's "Outlines of Palaeontology" (E. Arnold) gives an account of the development of the even-toed branch of the Ungulates.

LESSON 28

From Brute to Man:
The Story of Human Evolution

(See Colour Frontispieces)

FOSSILS of early Man and of the anthropoid apes are rare, and it is impossible, up to the present, to give as detailed an account of the evolution of Man as that of the evolution of the horse. Fresh discoveries are continually being made, however, and already we can trace many of the changes involved in the development of the physical characters of Mankind. The chief factor which caused early Man to diverge from the ape stock was growth of brain, which appears to have been facilitated by Man's longer period of gestation (280 days in Man, as compared with 220 days or less, for apes). This longer period of gestation meant a delay in the hardening of the skull, and, therefore, a greater period during which the brain could grow; moreover, the sutures between the bones of the human skull do not completely close till the thirtieth year, while in apes and other

mammals these gaps are closed, and the size of the skull fixed, a year or two after birth. Another significant feature for brain growth which is taken into account in the classification of fossil skulls is the bony ridge over the eye. These supraorbital ridges are very prominent features in the gorilla's skull and in the skulls of some early types of men They are prominent in the Neanderthal and Rhodesian skulls, for example, and constitute a bony base for the attachment of the muscles which work the heavy lower jaw. When these ridges are prominent, the lower jaw is usually very massive. As Man evolves, he uses his hands more, and his teeth less, for tearing his tood and for fighting. His lower jaw becomes smaller, the brow ridges disappear, and his forehead extends forward and makes room for a larger brain.

Apes and Men. Man is a member of a group of climbing mammals. His front limbs firmly fixed at the base by a collar bone, his grasping hands, flat nails, and certain features of his brain place him in the same group as monkeys and apes. The most primitive representatives of this group today are the lemurs, fossils of which are known from the Eocene period onward. Lemurs live today chiefly in Madagascar, which, like Australia, has been isolated from the rest of the world, so that higher forms have not reached it.

An allied animal—the tarsier—living in the Philippines, has a flat face, large forward-looking eyes, and the power of holding itself erect and leaping on its hind legs. From some such lowly form as this evolved the separate branches of the Primates—monkeys, apes and men.

Fossil bones of the earliest ape-man known were found in Java in 1892. They consist of (1) the vault of the skull; (2) a left thigh bone; (3) three teeth. The thigh indicates that this strange creature walked nearly erect and was about 5 feet 6½ in. in height, and the skull is estimated to have a brain capacity of 900 cubic centimetres. In human races, the average brain capacity is 1,400 cu. cms., and ranges from 930 to 2,000 cu. cms. In all known cases where the brain capacity has been less than 900 cu. cms., it has belonged to an idiot. In gorillas, the brain capacity rises to a maximum of 610 cu. cms., so that the Java primate (*Pithecanthropus*), though less than human, was more than ape, and had reached a stage of transition which was almost human in gait and stature and almost human, but not quite, in brain. In "The Antiquity of Man," Sir A. Keith assigns

flowers resembling those of the last order in structure. Rushes (*Juncus*) and wood-rushes (*Luzula*) are included in this family. (c) The snowdrop family (*Amaryllidaceae*): as *Liliaceae*, but with an inferior ovary. Snowdrop (*Galanthus nivalis*) and daffodil (*Narcissus*) are examples. (d) The iris family (*Iridaceae*): as last family, but only three stamens Iris, crocus, gladiolus, and saffron (*Colchicum*) are good examples.

Order 6. Scitaminales. Tropical plants with large leaves and irregular flowers, of which the inferior ovary is generally divided into three compartments. The following belong to this group: banana (*Musa sapientum*), plantain (*M. paradisiaca*), ginger (*Zingiber*), Indian shot (*Canna*) and arrowroot (*Maranta*).

Order 7. Orchidales. Flowers irregular and of remarkable form. The stamens are reduced in number and united with the pistil. The orchid family (*Orchidaceae*): this is the second largest family of seed-plants, only being excelled in size by the *Compositae*, and including over 8,000 species. There is usually but one stamen. We have a few British orchids, but the headquarters of the family are in the tropics.

For practical work in relation to this and the previous Lesson the student would do well to obtain a simple flora with a key to the identification of wild flowers, and then collect as many wild flowers as possible; with the aid of the key and a hand lens he can then track down the flower to its specific name. The features on which classification is based will thus be better understood and appreciated than by reading through the text on classification with no study of flower structure.

LESSON 25

Plants that Prefer a Water Habitat

(See plate 32)

In Nature, plants generally grow together in communities, the individual members mutually affecting one another and accommodating themselves to all the circumstances of their environment. The different conditions afforded by the environment are spoken of as factors, which are both physical (those due to soil and climate) and biological (those produced by other plants and animals). The situation in which a plant grows is termed its habitat. We have already seen that there is a

certain relation between the plant and its surroundings. Thus, plants growing in the shade spread their leaves in the best position to receive light, climbers depend upon the presence of some suitable support, and animals are often necessary for pollination or seed dispersal.

The conditions of the soil have a very marked effect on determining the character of the vegetation present. Among the most important soil factors are the texture and the amount of humus (organic matter from decayed plant and animal remains). On these depend other important factors: the water content and the air content, as well as the chemical nature of the soil, especially whether its reaction be acid or alkaline.

Rainfall is the most important climatic factor. Variation in temperature in different regions of the earth or at different altitudes also has a pronounced effect. Other climatic factors which influence the vegetation are intensity of light and degree of exposure to the wind.

The effects of the biological factors are many and varied. Plants compete with one another to obtain food and light; twiners get support from their erect companions, while parasites, insectivorous plants and herbivorous animals are further obvious examples of the ways in which a plant is influenced by its relations with other plants and animals. Many plants possess means of defence against herbivorous animals These may take the form of spines, as in holly (whose lower leaves usually have spiny margins, while those near the top of a tall bush are without spines), or of distasteful substances, such as poisons in foxglove and deadly nightshade, or of needle-like crystals in the cells, or of stinging hairs.

Characteristics of Water Plants. In a consideration of environmental influences, water occupies an all-important position, and we now turn to some of the characteristics shown by plants which grow submerged or partially submerged in water. Such plants are collectively spoken of as hydrophytes, and examples are furnished by the water lilies, water buttercup, pondweeds, arrowhead, duckweed, water soldier, frogbit and bladderwort. We shall not here consider the *Algae* (green pond-scums, brown and red seaweeds), which live almost entirely in water, but confine our attention to the higher flowering plants.

In the case of streams, the rate of flow markedly affects the character of the flora. Where the current is rapid all the forms

are fixed by their roots in the bed of the stream, but in quiet water free-floating (i.e not fixed) aquatics will be present. Again, many species that grow above the water level in quiet water remain completely submerged in a rapid current.

The submerged parts of all water plants are surrounded by a medium very different from that which surrounds the over-ground organs of ordinary land plants, and in this connexion there are many modifications of their structure. First, water is far denser than air, and, consequently, can give support to the plants inhabiting it. Water plants, therefore, never possess an extensively developed vascular system. The chief strain to which their stems or leaf stalks are subjected is a longitudinal pull due to currents in the water, and thus the small amount of mechanical tissue which the aquatic possesses is arranged as a central core, as in the root of a land plant

Water plants do not depend on their roots for the absorption of water and mineral salts. The roots serve chiefly for attachment, and absorption is carried on over the whole of the submerged surface. This, then, is a second reason for the lack of development of woody tissue, since conduction from the roots by way of the wood vessels is not necessary.

The oxygen essential for respiration is present in very small amounts in water, but carbon dioxide, which dissolves readily in water, is present in abundance There are no pores on the submerged parts of the plants, so that all gaseous exchange must take place by diffusion through the cuticle (the outer wall of the epidermal cells). The difficulties concerning gaseous exchange are compensated by very thin foliage leaves, or extreme division of their blades, which thus creates a large absorptive surface. Owing to the relatively great amount of carbon dioxide, photosynthesis takes place readily, and the oxygen which is set free in this process is stored up within the plant for use in respiration. This reserve of oxygen is held in the numerous large air spaces which traverse all parts of the aquatic plant. These air-chambers are also useful in rendering the plant buoyant, thus helping to maintain it in an erect position. A similar system of air passages is present in the underground organs of marsh and swamp plants, which have the same difficulty of obtaining sufficient oxygen.

Submerged aquatics are obviously exposed to very reduced illumination, owing to much light being reflected from the surface of the water, and the remainder being rapidly absorbed

certain relation between the plant and its surroundings. Thus, plants growing in the shade spread their leaves in the best position to receive light, climbers depend upon the presence of some suitable support, and animals are often necessary for pollination or seed dispersal.

The conditions of the soil have a very marked effect on determining the character of the vegetation present. Among the most important soil factors are the texture and the amount of humus (organic matter from decayed plant and animal remains). On these depend other important factors: the water content and the air content, as well as the chemical nature of the soil, especially whether its reaction be acid or alkaline.

Rainfall is the most important climatic factor. Variation in temperature in different regions of the earth or at different altitudes also has a pronounced effect. Other climatic factors which influence the vegetation are intensity of light and degree of exposure to the wind.

The effects of the biological factors are many and varied. Plants compete with one another to obtain food and light; twiners get support from their erect companions, while parasites, insectivorous plants and herbivorous animals are further obvious examples of the ways in which a plant is influenced by its relations with other plants and animals. Many plants possess means of defence against herbivorous animals. These may take the form of spines, as in holly (whose lower leaves usually have spiny margins, while those near the top of a tall bush are without spines), or of distasteful substances, such as poisons in foxglove and deadly nightshade, or of needle-like crystals in the cells, or of stinging hairs.

Characteristics of Water Plants. In a consideration of environmental influences, water occupies an all-important position, and we now turn to some of the characteristics shown by plants which grow submerged or partially submerged in water. Such plants are collectively spoken of as hydrophytes, and examples are furnished by the water lilies, water buttercup, pondweeds, arrowhead, duckweed, water soldier, frogbit and bladderwort. We shall not here consider the *Algae* (green pond-scums, brown and red seaweeds), which live almost entirely in water, but confine our attention to the higher flowering plants.

In the case of streams, the rate of flow markedly affects the character of the flora. Where the current is rapid all the forms

are fixed by their roots in the bed of the stream, but in quiet water *free-floating (i.e not fixed) aquatics* will be present. Again, many species that grow above the water level in quiet water remain completely submerged in a rapid current.

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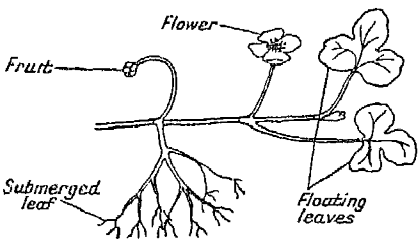
Submerged *aquatics are obviously exposed to very reduced* illumination, owing to much light being reflected from the surface of the water, and the remainder being rapidly absorbed

as it penetrates to deeper levels. Most water plants, therefore, bring their leaves (the assimilatory organs) as near to the surface as possible. It is the light factor which determines the depth at which submerged plants can grow

We have already mentioned that the submerged foliage may consist of finely divided leaves; this is well seen in the water buttercup. Such deep division has also a mechanical advantage, in that the water flows readily between the segments without tearing them. The fennel-leaved pondweed has long linear, undivided leaves which readily trail out with the current. Submerged leaves which have a broad surface are always very thin and flexible.

The water buttercup illustrates well the general rule that when floating leaves are produced, they are quite different in form from the submerged leaves The yellow water lily is the most familiar exception to this; the leaves are similar in form, but the submerged ones are very much thinner. Floating leaves mostly agree in having an entire edge, and the petiole attached more or less centrally, so that the pull of the leaf stalk keeps the blade flat on the water. Unlike submerged leaves, they bear stomata. The latter are, however, confined to the upper surface, which usually has a covering of wax (leaving the pores free); this covering prevents wetting and blocking of the pores. Connexion is thus maintained between the air spaces of the submerged organs and the outside atmosphere The floating leaves also form a supporting platform round the base of the flower stalks, which, in the majority of aquatics, bear the flowers above the water level.



WATER BUTTERCUP. Diagram showing the contrasting forms of floating and submerged leaves of Ranunculus aquatilis

The roots of water plants serve mainly for attachment Some have no roots at all (e.g. bladderwort), while in free-floating forms, such as the duckweed, the roots dangle into the water and not only absorb, but also act like a weighted keel to keep the plant properly balanced.

The abundant supply of water, and often of mineral salts as well, enables water plants to grow rapidly and prolifically. In view of this, vegetative reproduction is generally a marked feature. A simple method, common in the Canadian pondweed (which was at one time a serious pest in canals on account of its rapid growth), is the mere detachment of branches, which grow into new plants. Many forms produce winter buds, which, when the parent plant dies, sink to the bottom of the water and give rise to new plants in the following spring.

The flowers are, in the majority of cases, borne above the water level, which indicates that water plants are derived from land plants. They may be pollinated by insects (e.g. water buttercup) or by wind (e.g water milfoil). Usually the flower stalks bend after flowering is over and carry the ripening fruits under water, so that they are well protected. A few aquatics are so highly adapted to life in the water that they even produce submerged flowers. The pollen is conveyed to the stigmas by currents of water. Corresponding with this uncertain method of pollination, a large amount of pollen is produced as in the case of land plants pollinated by wind.

LESSON 26

How Plants Prepare for Drought

(See plate 33)

In very striking contrast to aquatic vegetation, which we considered in the preceding Lesson, are the plants which inhabit dry situations, such as dry heaths, shingle banks, sand dunes and deserts. Such plants are termed xerophytes, and the problems confronting them are entirely different from those which have had to be solved by the aquatics. The soil of such places retains very little water, it is often so loose that it is shifted by the wind; organic matter is scarce, and the rainfall often small. In such places also there is little or no shade from the sun, and no protection from the wind. Water supplies are, therefore, very meagre, and risk of loss of water by evaporation is very great. The plants must obtain water somehow from the soil, and retain as much of it as possible, in order to maintain their cells in a turgid condition.

Deep roots are an obvious necessity for plants growing in such

habitats With sufficient depth of root a plant can remain fixed even if the surface layers of sand are blown away by the wind ; also, at a depth of a few feet the roots are bound to come on soil in which there is a certain amount of moisture. Some transpiration must take place in order to make use of the water which is absorbed, but it must be reduced to a minimum. The development of special water-storage tissue is an advantage; the plant with reserve supplies is then enabled to withstand periods of drought.

All plants that thrive in dry habitats do not adopt the same solution to the problem of their water supply. The possession of deep roots or underground stems bearing roots is very general, but more than one device is shown for lessening transpiration.

Devices for Reducing Transpiration. The marram grass is an excellent example of a xerophyte possessing deep underground stems. The plant abounds on sand dunes, and is often planted to bind together the loose shifting sand by means of its long rhizomes and roots. The leaves are about 3 ft high, with very sharp hard tips, which can force their way up without injury through the sand, should it bury them The aerial stems also force their way up to the surface, and frequently send out new rhizomes a few inches below the new surface. This extensive underground system of rhizomes bearing roots is occasionally brought to view by wind blowing away much of the sand. Rhizomes have been found measuring over 20 ft. in length.

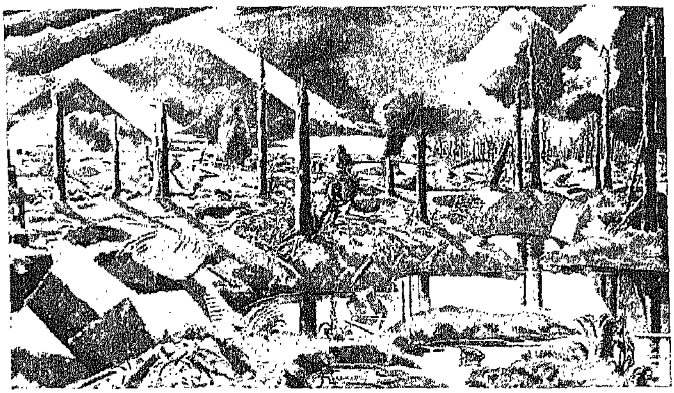
The leaves of the marram grass are beautifully adapted for reducing transpiration to a minimum. In damp weather the blades are flat, like those of an ordinary inland grass ; but in dry weather the two edges of each leaf roll together, so that the leaf appears as a long narrow cylinder. The leaf bears its stomata (through which water vapour is lost) on one surface only, and it is this surface which lies on the inside of the cylinder. This surface of the leaf is deeply grooved, and the stomata are still further protected from currents of air by lying near the bottom of the grooves, and by having hairs growing from the intervening ridges. The curling up of the leaf in dry weather and its flattening in moist conditions are caused by changes in turgidity of the thin-walled " hinge cells " situated at the bottom of the grooves.

Rolled leaves which serve the same purpose are characteristic of many plants growing on exposed heaths, e.g. the cross-leaved

DEVELOPMENTS IN MODERN PAINTING. Left, "Pierrot," an early work of Pablo Picasso (b. 1881) one of the founders of Cubism. Above, "La Mitrailleuse," by C. W. R. Nevinson; it depicts French soldiers in a trench and tense horror *is emphasized by the uncompromising treatment of* straight lines throughout.

ART AND ARCHITECTURE 22

Left photo by permission of Alex. Reid & Lefèvre, Ltd.; above, National Gallery, Millbank



LANDSCAPES OF WAR AND PEACE. Widely contrasted are these two paintings by the brothers Paul and John Nash born respectively in 1889 and 1893. In his powerful war picture "Menin Road," Paul Nash conveys the stark tragedy of desolation by the still upright though shattered trees and the water-filled shell-holes. "The Lane" (above), a water-colour by John Nash, is a simplified design of the homely countryside on a grey day. ART AND ARCHITECTURE 22

Lower, Imperial War Museum; upper, National Gallery, Millbank

heaths (*Erica tetralix*). The leaves of these plants are usually small and thick-skinned. The ling (*Calluna vulgaris*) has very small leaves, which are V-shaped in cross-section and arranged in four vertical rows on the stem. In dry weather they fold in tightly, one upon the other, and thus each is protected from the surrounding air by its neighbour below.

Gorse is very abundant on heaths and commons. It is enabled to withstand dry conditions by the possession of very small leaves, many of which are modified into hard dry spines. Thus, not only is the transpiring area of the plant reduced, but the plant is also protected from browsing animals When leaf area is reduced, it follows that the assimilating area is also diminished. To compensate this, the younger parts of the stem are green and thus able to help with carbon assimilation It is of interest to note that the first foliage leaves produced by a seedling gorse plant resemble clover leaves. This suggests that gorse once had compound leaves, and its success in dry habitats is due to suppression of its transpiring organs.

Broad-leaved plants which occur in dry situations have various devices for checking transpiration: the leaves of the yellow-horned poppy are covered with a felt of hairs; those of sea holly bear a bloom of wax; those of the sea pea and sea bindweed have a very thick cuticle. The plants just mentioned grow on shingly beaches or sand dunes.

Water-storage Tissue. The development of special water-storage tissue, resulting in "succulent" fleshy leaves or stems, is met with in many xerophytes. Succulence is most highly developed in cactus plants, characteristic of desert floras; in these the leaves are greatly reduced and represented only by prickles or spines, while the stem swells up, stores water and does the work of the leaves. Frequently a waxy bloom is combined with the succulent habit. The most common British xerophytes showing succulence are the stonecrops (*Sedum*) and the house leek (*Sempervivum*), often seen on rockeries, walls and roofs.

Many plants which grow in salt marshes near the sea exhibit the same modifications of structure to reduce transpiration as do those in dry places, and, particularly, possess the succulent habit. Examples of salt marsh plants are the glasswort (*Salicornia*), the cord grass (*Spartina*), sea lavender (*Statice*) and sea plantain (*Plantago maritima*). Salt marshes are areas which are periodically inundated by the tides, and left as large tracts of

mud intersected by water-channels and pools. There is obviously no shortage of water, but the content of sodium chloride is very high If, therefore, the plants were to absorb large quantities of sea-water and transpire rapidly, great accumulations of salt would occur in their cells and be injurious to their tissues. It is probable that salt marsh plants, although surrounded by water, really absorb very little of it, possibly only at such times as the salt content is sufficiently reduced by the addition of fresh water at heavy rainfall.

Woodland Plants. In all woods trees are the most conspicuous feature of the vegetation Beneath the larger trees there are usually stunted ones, saplings and shrubs, forming an undergrowth, and a carpet of herbaceous plants forming the ground flora. The dominant type of tree in a wood depends usually on the type of soil, e.g. beech and ash on chalky (calcareous) soil, birch and oak on non-calcareous soil The character and amount of undergrowth depend on the dominant tree. In a beech wood there is very little undergrowth ; this is due to lack of light caused by the extensive branching and perfect leaf-mosaic of the beech trees. Also, beech leaves rot down very slowly, and thus there is not much available humus in such a wood. In the autumn many fungi are seen on the ground , these, being saprophytes devoid of chlorophyll, can flourish in the deep shade.

Of a different character is an oak wood. These trees cast far less shade than the beech ; consequently, there is abundant undergrowth. Usually hazel is the commonest shrub, and with it often occur bushes of hawthorn, sloe, dog-wood, spindle, willows, and the climbing briars and honeysuckle. In early spring the ground flora consists of dog's mercury, wood anemone, violets, lesser celandine, primrose and many others, to be followed by the bluebells, and a little later the pink campion, white and yellow dead-nettle, wood spurge, foxglove, etc. It will be noticed that the earliest flowering herbs frequently possess underground storage organs. These food stores enable the plants to make rapid growth as soon as the weather permits, and, therefore, to build up fresh foods for the following year before the taller plants overshadow them. Again, those that depend on insects for pollination are able to show their conspicuous flowers before the overhead canopy obscures them.

The numerous plants found in such a wood are necessarily competing with one another for food from the soil. Owing

however, to the different depths to which the roots of trees, shrubs and herbs penetrate the soil, this competition is not as great as it might be. The chief benefit which small woodland plants derive from their habitat is in the form of shelter from sun and wind; they can, therefore, afford to spread their leaves as much as possible to facilitate the process of photosynthesis without running any risk of excessive transpiration. The dying down of the ground flora and subsequent rotting of leaves and stems enrich the soil with humus, which is greatly to the benefit of the larger trees.

The student, for practical work, should, whenever possible, note the different types of plants growing in different habitats. Uprooting one or two examples, he should note whether shallow- or deep-rooted; observing the general mode of growth and, particularly, the leaf characters, he should try to see how the plants are adapted to their environment. He should study the soil character for any habitat under investigation, noting whether it is chiefly clay, sand, gravel or chalk, and whether humus (characterized by a very dark colour) is present. A list of the plants found should be made and compared with the flora of other types of soil.

LESSON 27

Classification of the Gymnosperms

(See plate 34)

All living seed-plants are grouped as *Phanerogams*, which class is subdivided into angiosperms and gymnosperms, according to the way in which the ovules are borne. As already mentioned in Lesson 23 (page 146), gymnosperms are naked-seeded plants, that is, the ovules are not borne within an ovary. They include the following four groups:

1. *Ginkgoales*, represented by only one living species, the maiden-hair tree (*Ginkgo biloba*), a native of eastern Asia.

2. *Cycadales*, the cycads, a small group of comparatively lowly forms, which in past geological times were very numerous and widely distributed. They are limited to the hotter parts of the globe, especially Central America and Australia. A cycad somewhat resembles a palm in appearance, but has usually a much shorter trunk.

3. *Gnetales*, a small group of only three genera, which differ greatly from one another in general appearance and are limited to the hotter parts of the globe. *Welwitschia*, which occurs in the deserts of south-western Africa, somewhat resembles a giant radish in having a swollen underground hypocotyl which may exceed four yards in circumference. The plant bears only two leaves, which are over two yards long, and lie flat along the surface of the soil. *Ephedra* may be described as a switch plant, having thin, long-jointed green stems and minute scaly leaves. It occurs in the deserts of western Asia. Members of the third genus, *Gnetum*, are mostly climbers (lianas) from tropical Asia and America; their leaves resemble those of angiosperms in being broad with a network arrangement of the veins. This entire group shows an approach to the angiosperms in the fact that their small flowers possess a perianth, which is absent in other gymnosperms.

4. *Coniferales*, the cone-bearing trees. The great majority of gymnosperms belong here, familiar examples including the monkey puzzle (*Araucaria*), pines (*Pinus*), firs (*Abies*), spruce (*Picea*), cedar (*Cedrus*), larch (*Larix*), cypress (*Cupressus*), juniper (*Juniperus*), and yew (*Taxus*). Many of them are forest trees of considerable size, and in some parts of the world they cover large areas, as, for instance, in the cooler parts of the northern hemisphere. Among them are the gigantic Wellingtonia (*Sequoia gigantea*) and redwood (*S. sempervirens*) of North America. The former may attain a height of over 460 ft., with a trunk of 112 ft. in circumference (*see* illus., Vol. 2, Plate 22). Many conifers are of very great economic value, furnishing "soft wood" timbers, turpentine, resin, etc. There are about 350 known species, of which more than a fifth belong to the genus *Pinus*.

All the members of this group are woody, and the majority are evergreen trees, with leaves which persist for three or four years. The larch, however, is deciduous, i.e., sheds its leaves annually. The most distinctive external feature of the group is the foliage, which, in general, consists of small "needles." The simple flowers are of two kinds, male and female, which in nearly all cases are in the form of cones and possess no perianth.

Structure of Vegetative Organs. The general anatomy of stem and root of the conifers shows close agreement with that of the dicotyledons, which we considered previously (Lesson 23)

in some detail. The distribution of tissues is similar, and both show increase in thickness from year to year by the activity of a layer of cambium. A striking feature in the cortex of the stem of a conifer is a ring of large resin canals. Each canal is an intercellular space surrounded by small cells, rich in protoplasm, which secrete the resin into the canal. These canals are found in all parts of the plants (except in yew from which they are entirely absent). The resin is a protection to the plant against animals; it renders the young twigs distasteful.

A detailed examination of the wood and bark shows some marked differences in structure between the conifers and angiosperms. For example, in the wood of the conifers there are no conducting vessels, but conduction of water, etc., is performed by single elongated cells known as tracheids. This, and other structural differences, show that the group is fundamentally distinct from the dicotyledons.

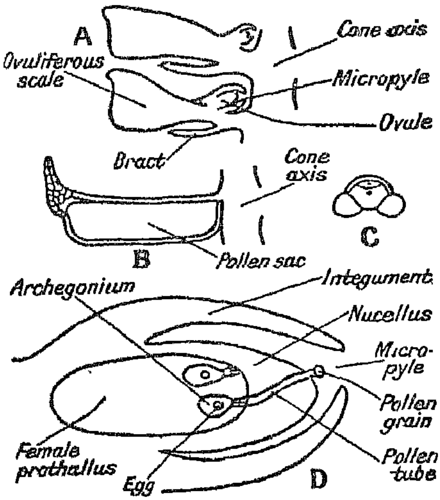
The leaves differ greatly from typical leaves of dicotyledons, being usually of simple structure and often traversed only by one small vein. The needles show many characters which are *associated with reducing transpiration, e.g. a thick cuticle and* protected stomata. The lack of side-veins is compensated for by a special tissue, known as transfusion tissue which surrounds the vein and is a characteristic feature of the conifers. In several common genera (e.g. *Pinus*, *Cedrus*, *Larix*) the needles are borne on special "dwarf shoots," which arise in the axils of scale leaves on the ordinary long shoots, and bear a few brown scales below and a variable number of foliage leaves above. In the pines the entire dwarf shoot falls from the tree when the leaves are shed.

Reproductive Organs. It is in the flowers and the processes of pollination and fertilization that the gymnosperms show the most marked differences from the dicotyledons, and, to illustrate this, we will take as our example the Scotch fir (*Pinus sylvestris*). The male and female flowers are borne in separate cones, but both sexes occur on the same plant. The male cones are small yellow oval structures, usually borne in clusters. The central axis of each cone bears numerous scale-like stamens, obviously more leaf-like than the stamens of angiosperms. On the under side of each scale are two large pollen sacs, which, when mature, split widely open to liberate the pollen, which is distributed by wind. Each pollen grain is provided with two bladder-like

expansions of the cell-wall which act as wings and so enable the pollen to be carried long distances.

The female cones of the Scotch fir first appear as small reddish structures just beneath the apical bud of a shoot. Each is borne on a short stalk The central axis of the cone bears the ovuliferous scales, each of which bears two ovules on its upper surface near to the cone axis Beneath each ovule-bearing scale is a small sterile bract.

Each ovule lies with its micropyle towards the cone axis; each is surrounded by a single protective coat or integument, and contains a large embryo sac. At the time of pollination the scales of the female cone are slightly separated from one another, so that the pollen grains can get blown between the scales and reach the micropyle. A small quantity of liquid is secreted just within the micropyle, and to this the pollen grains adhere. A long interval occurs between pollination and fertilization, amounting to over a year in the pines, where pollination takes place in May of one year, but fertilization is not effected until June of the next year. Pronounced growth of the female cones occurs in this interval, accompanied by complete development of the ovules



PINUS SYLVESTRIS: REPRODUCTIVE SYSTEM
A, part of longitudinal section of female cone. B, single stamen of male cone. C, winged pollen grain. D, ovule contained in female cone.

When ready for fertilization the ovule presents a very different structure from that seen in angiosperms. The large embryo sac is filled with tissue rich in food material. This feature is characteristic of all gymnosperms, and is one of the most important distinctions between this class and all other flowering plants.

Embedded in this tissue (the female prothallus), at the micropylar end, are a few flask-shaped organs known as archegonia, in which the egg nuclei are held.

A short time before fertilization the pollen grains germinate and put out long tubes which grow down to the archegonia. The nucleus of the pollen grain has undergone several divisions, its most important products being the two male nuclei, one of which fertilizes the egg nucleus in the archegonium, while the other degenerates. The outcome of fertilization is the development of a young embryo within the ripening seeds; the entire cones undergo considerable enlargement, becoming very woody; when ripe, the cone-scales gape apart to set free the winged seeds, which are dispersed by wind.

Ginkgo (the maiden-hair tree) and the cycads are of great interest, because they show a transition from the methods of fertilization of other phanerogams and the methods we shall notice in considering the lower types of plants. Pollen tubes are produced from the pollen grains, but the male nuclei have to complete their journey to the egg nucleus by means of their own movements. They are provided with thread-like appendages called cilia, and by moving these threads they swim to the archegonia in a slimy fluid which is secreted by the female organ. Such motile gametes are known as spermatozoids, and, with them, fertilization is dependent on the presence of a certain amount of liquid. In the conifers, which have no necessity for the presence of liquid at fertilization, we may see the loss of the last traces of the probable aquatic ancestry of the vegetable kingdom.

Our Course in Botany is continued in Volume 5,

LESSON 7

Wars and Revolts of the 15th Century

(See plate 35)

TOWARDS the end of the 14th century the strength of Parliament—of the House of Commons in particular—had been growing, and in the beginning of the 15th, for 50 years, it reached a peak of development only arrested by the Wars of the Roses In 1399, by lying promises, Henry of Lancaster had induced Richard II to place himself in his power. Having pretended that he would help the king to govern better, he imprisoned him in the Tower, and there forced him to sign his abdication, which Parliament immediately accepted. The throne being empty, Henry stated his claims to it. Parliament, in assenting, reverted to the old right of election and to the precedent supplied by the deposition of Edward II. Richard's heir by right of succession was Edmund Mortimer, great-grandson of Lionel, duke of Clarence, second son of Edward III. Henry was the son of Edward's third son, John of Gaunt. In passing over the claims of Edmund Mortimer—a small boy at the time, but who might, and did, become a rallying-point for rebellion—and in the acceptance of Henry as king, Parliament gained a hold upon the dynasty of Lancaster. The constitutional problem was here solved by parliamentary choice—representative of the barons and of the nation at large—and not by hereditary right of descent. From the accession of Henry IV the members of the royal council were nominated, and their salaries, rules, and procedure governed by Parliament.

Henry's reign was consequently a troubled one. He was bound to consider the wishes of Parliament to a greater extent than his predecessors. After a rebellion in 1400 had been ruthlessly suppressed, the unfortunate Richard died in circumstances suspiciously like murder. It was generally believed that he had been put to death by Henry's command, but the latter declared that Richard committed suicide by voluntary starvation.

The Percy Rebellion. A quarrel with the most prominent of his former supporters, the earl of Northumberland, over the

ransom of Scottish prisoners taken in a border raid, was the occasion of a dangerous revolt, nominally on behalf of Edmund Mortimer, the young earl of March. Northumberland's son, Henry Percy—known better as Harry Hotspur—had married Edmund Mortimer's aunt. Other causes irritated the Percy family and they marched against the king, but were completely defeated at the battle of Shrewsbury, where Hotspur was killed. Northumberland, soon after taken prisoner, was only pardoned on oath of complete submission After the Percy rebellion, except in Wales where rebels headed by Owen Glendower—who wished to make Wales independent and proclaimed himself its prince—were in arms throughout the reign, there were no more active insurrections.

Battle of Agincourt. Henry IV died, a worn-out man, before he was fifty Henry V (1413–22) added lustre to the English arms by renewing the war with France, winning a victory at Agincourt as astonishing as those of Crecy and Poitiers, reducing Normandy by a systematic succession of sieges, making himself master of north France by alliance with the powerful Philip, duke of Burgundy, and securing—on paper by treaty with the half-mad king, Charles VI, whose daughter Katharine he married—the succession to the throne for himself and his heirs. At the age of thirty-three Henry V died on campaign, leaving the French and English crowns (since Charles VI also died within a few weeks) to the year-old infant, Henry VI (1432–61)

Thirty-one years later all that Henry V had won was lost, and more. Of all that England had ever held in France, nothing remained but Calais. After 1438 the gains were all on the French side. With a mistaken sense of national pride the English persevered with the disastrous war until 1453, although the country grudged all money and men sent across the Channel. Siege artillery was used most effectively by the French to batter the English out of their various strongholds

End of the Hundred Years' War. Henry's brother, John, duke of Bedford, appointed regent in France, had striven to carry through the policy of conquest bequeathed to him He was hampered by the intrigues of his brother, Humphrey of Gloucester, Protector in England on behalf of the infant king. When Joan of Arc had led the French to victory after victory—till she was captured by the Burgundians, condemned as a heretic by an ecclesiastical court, and handed over to the English

to be burnt at the stake (1431)—matters went continually from bad to worse Bedford died · Burgundy joined the French king Charles VII, whom Joan had crowned ; the English nobles broke up into factions and after a desperate effort to save Guienne, in 1453, nothing remained but Calais The Hundred Years' War was finished

Wars of the Roses. From 1422 to 1447 England was disturbed by the rivalry of Beaufort and Gloucester The Beaufort family was headed by the bishop of Winchester Chancellor of England and afterwards Cardinal, and his brothers, who were illegitimate half-brothers of Henry IV This rivalry between the Beauforts and Gloucester continued after Bedford's death, the Beauforts becoming a peace party, while Gloucester, as leader of the war party, was supported by young Richard, duke of York. The last named derived his title through his father from a younger son of Edward III, but through his mother was heir to all the claims of Edmund Mortimer, who had been passed over when Henry IV was made king. Gloucester fell into disgrace. He had been forced to renounce the Protectorship when Henry VI was crowned. York was sent to France, and the Beauforts dominated England and negotiated the king's marriage with Margaret of Anjou, a princess of strong and fierce personality, who was henceforth closely associated with their party.

The marriage was very unpopular ; Gloucester was murdered ; his death made Richard of York heir presumptive to the throne, as there was no other prince of the blood royal between—except the Beauforts, who, though illegitimate, evidently meant to assert a claim if the king should die childless. Richard showed no disloyalty, but claimed the authority in the government due to his position There was a prolonged political struggle between him and Margaret. The prospect of his hereditary accession faded with the birth of a son to Henry and Margaret, but Parliaments of 1450–51 were strongly on the side of Richard. At last war broke out between the supporters of Lancaster and York, and Richard claimed the succession in priority to the prince of Wales, as the true heir of Edward III. Margaret was ready to fight like a tigress for her son, and the first of the fourteen battles of the Wars of the Roses was fought at St. Albans, 1455, in which York was victorious. Richard, however, was defeated and killed at Wakefield (1460) Then his son Edward defeated a Lancastrian force at Mortimer's Cross, marched to London,

where he was proclaimed king, and shattered the Lancastrians at Towton (1461). Henry and Margaret had to flee the country.

Edward IV (1461–83) owed his crown in great part to his cousin, Richard Neville, earl of Warwick, who is called Warwick the kingmaker, and who was the real ruler until he discovered that Edward was planning to get rid of him. In his wrath he went over to the Lancastrians, drove Edward out of the country, and set Henry—who had been captured some time before and shut up in the Tower—on the throne again (1470). But Edward returned, defeated and killed Warwick at Barnet, and completed the overthrow of the Lancastrians at Tewkesbury (1471). Henry, back in the Tower, was murdered; his son, the prince of Wales, had been either killed in the battle or captured and murdered afterwards. Thus the dynasty of Lancaster came to an end.

To resist Edward was now impossible. The Lancastrian nobles were all dead or in exile; they had no figure-head except the boy, Henry Tudor, earl of Richmond, an exile in Brittany, whose mother was a Beaufort. Edward reigned as an absolute monarch for twelve years. Then he died suddenly. His brother Richard of Gloucester seized the crown before the child-heir, Edward V, could wear it. The whole world believed that the boy king and his brother were murdered in the Tower. Our knowledge of Richard's reign and character is derived entirely from the historians of the next reign, who painted him in the blackest possible colours and certainly attributed to him crimes which he could not have committed, and Shakespeare has made that picture indelible.

However exaggerated this view may be, his rule was so intolerable that Yorkists at home conspired with Lancastrians abroad to set Henry of Richmond on the throne in Richard's place, and to end the feud of the Roses—the red the badge of Lancaster and the white that of York—by marrying him to Edward IV's daughter, Elizabeth. When Richmond landed at Milford bay, Richard, marching to meet him, was deserted by half his followers and lost his crown and his life, fighting magnificently to the last, on Bosworth field (1485). So fell the last of the Yorkist kings, and the crown of England passed to the Tudors.

LESSON 8

England on the Eve of the Reformation

(See plate 36)

THE reign of Henry VII (1485–1509), the first Tudor king, marks the transitional period from the medieval to the modern world. In 1492, Christopher Columbus, backed by the Spanish monarchy, set sail west instead of east to find a new trade route to India In ten weeks he had reached the Bahamas—and suddenly the size of the known world had expanded with the addition of a new hemisphere. Spain and Portugal reaped the immediate material wealth and glory. England had no commercial share in the discoveries till after the middle of the 16th century but the effect on the mental attitude of her scholars and thinkers was revolutionary Expansion of ideas followed the physical widening of space.

During the 15th century the disintegration of old ideals had proceeded now the Renaissance was emerging. Printing presses were at work in England the new learning and revival of the classics were advancing quickly at Oxford, but so far had not come into opposition with the Church Diplomacy was making headway in foreign affairs, but the theory of the balance of power was not developed till the reign of Henry VIII.

Henry Tudor. The Wars of the Roses proved to be the deathblow to English feudalism Henry Tudor possessed a strong character and remarkable astuteness He had the highest reputation for statesmanship, and restored England's lost position as a European power ; but, in addition, he put his own house in order. He founded a strong dynasty, and set the keynote of a successful policy at home. Lack of funds and the slenderness of his title to the throne might have kept Henry dependent on Parliament. By the substitution of huge fines and confiscations of property for the death penalty of treason, he filled his exchequer and also completed the fall of the antagonistic baronial families ; by marrying Elizabeth of York, representative of the rival house, he strengthened his title to the throne.

At the opening of his reign, despite the wars, the rural population in England was moderately prosperous, but unfortunately did not retain prosperity The growth of the wool industry

had increased the demand for sheep consequently arable land had been turned into pasture and much common land had been enclosed Justifiable discontent arose out of this, as agriculture had employed more labour and the small tenant was deprived of his waste land The capitalist who thus speculated in land brought about the abandonment of rural districts by the unemployed and the gradual increase of out-of-work poor in the urban districts. The Tudor period was individualistic and not social. The commercial connexion between landlord and tenant took the place of the feudal tie—cruel enough often, but still entailing personal responsibility—and the owner merely cared for making money, while his tenants' sole value to him was the profit they produced.

Besides the capitalist in land, two other types appeared: the manufacturer employing labour on a comparatively large scale, and the merchant who sold his manufactured goods. In the provincial centres the manufacturers established themselves, while the merchants had their offices in London.

Rising of Yorkist Pretenders. Until 1505 Henry was troubled with periodical insurrections on behalf of Yorkist pretenders, including that of Lambert Simnel, in 1487, and that of Perkin Warbeck, beginning in 1492 The king quelled these rebellions in characteristically vigorous but diplomatic fashion. During the seven years of the risings connected with Perkin Warbeck Scotland was involved, as James IV had received the impostor cordially under his guise of a Yorkist prince, and allowed him to marry his kinswoman. After the execution of Warbeck, Henry made alliances with Scotland and Spain. His daughter, Margaret, was married to James IV, and Arthur, his eldest son, to Catherine of Aragon. Arthur died, and after the death of Henry VII Catherine was married to Henry VIII, six years her junior.

Wolsey and the Renaissance. Henry VIII succeeded to a fairly ordered country. Ferdinand of Aragon, his father-in-law, and the Emperor Maximilian tried to draw him into war with France. England had nothing to gain by this, but the king was young and the country quite ready to use its restored strength in a war of aggression. The work of army organization was assigned to the king's almoner, Thomas Wolsey (1471–1530). In 1512 a brief campaign was started in France, but was a failure. Wolsey, however, proved the wariest and most diplomatic of statesmen in negotiating a peace which was in accordance with the prevailing

ideas of national greatness He himself believed that England would be more powerful in peace than in war and in this he reflected the spirit of the Renaissance This intellectual movement somewhat slow in reaching England, was based primarily on the desire to study the Greek language and classical culture. The most remarkable member of its protagonists in England was Sir Thomas More, the author of "Utopia," who longed for the king to abandon militarism and cultivate the arts of peace Wolsey, by 1515 Chancellor of England and a Cardinal was a great supporter of the Renaissance

He is sometimes called England's first great foreign minister, and it was his constant desire to hold the balance of power between Francis I of France and the emperor Charles V, grandson and heir of both Maximilian and Ferdinand of Spain

Fall of Wolsey. It is only since the publication of the State Papers of the period that Wolsey has received just acknowledgement as a great statesman He was unpopular, alike with commoners and nobles, on account of his ostentation and arrogance His downfall, however, was not due to his enemies, but to his inability in spite of his utmost diplomatic efforts, to persuade Pope Clement VII to annul, as head of the Christian world and the Christian faith, the marriage, solemnized by a papal dispensation, between Henry and Catherine of Aragon, the widow of Henry's deceased elder brother, Arthur Henry's conscience became for various reasons—chief amongst them the lack of a male heir—uneasy about this marriage it was certainly contrary to the law of the Church , had the earlier Pope authority to sanction it ? When to Henry's doubts was added a strong desire to marry Anne Boleyn, he insisted that the marriage was no marriage but public opinion required that the Pope should say so Clement was too much afraid of the emperor, who was Catherine's nephew, to commit himself , Wolsey, being half-hearted in the matter, failed to persuade him Henry had no more use for the Cardinal, who was presently charged with treason, though he died at Leicester on the way to his trial in London

Wolsey's fall was the first step towards the Reformation If the Pope would not give way, the papal authority in England must be repudiated altogether by a king on whom another Pope had bestowed officially the title of Defender of the Faith on account of his vigorous denunciation of the heresies recently propounded by Martin Luther

LESSON 9

The Reformation in England

(See plates 36 and 37)

AFTER the fall of Wolsey Henry, with the support of Parliament, embarked on his revolutionary course. There was one Church in all western Christendom, and all acknowledged the Pope as its head, in England as elsewhere; the only question, until Luther appeared concerned the precise extent of the papal authority The Church was international, taking no account of separate countries; but if the Pope refused to do what was in Henry's eyes his obvious duty, his divine authority was proved to be a fiction, and Henry, for England, would assume the authority himself. Being in his own view a pattern of orthodoxy the king had no intention of countenancing heresy and adopting the new doctrines of Reform, but the dissolution of the monasteries and the consequent redistribution of the national wealth were in accordance with the spirit of the age, and consequently a series of changes was inaugurated by Parliament during its sittings between the years 1529–34, which resulted in the annulment of papal authority in England.

In making these changes, which established the Reformation politically, Henry was therefore able to feel and to show that he had the support of the nation behind him. Most of the clergy even, unless they happened to be at cross purposes with the king, resented papal interference, though most would certainly resent no less the interference of any lay authority with regard to Church property or in ecclesiastical affairs Where they were in opposition they had to be coerced. Though the monks were easy, charitable and therefore popular landlords in the north and west country, they were not so highly esteemed in the east and south, and laymen generally were envious of the great wealth of the ecclesiastical foundations, the luxury in which many of the higher clergy were able to live, and their political influence —as in the case of the fallen Wolsey—and censured, or affected to censure, the reputed low standard of morality in the monasteries.

There was also an undercurrent—in spite of the general conservatism in matters of religion—of what was soon to be

called Protestant opinion, derived from the condemned teaching of John Wyclif in the days of Richard II—when it was called Lollardy—and unconsciously fostered by later scholarship Since 1410 English had begun to displace Latin in hymns and devotional primers At Oxford, in 1497–98, Colet had lectured in English on St Paul's Epistles and taken his hearers back to the literal meaning of the words The courtiers and new nobility that had sprung up on the ruins of the old had no desire to cross the king's will, especially if he penalized clerical opposition, to their own financial profit Clearly the will of the nation as expressed by Parliament was at Henry's back And he had found in Thomas Cromwell Wolsey's former secretary, a man who would carry out his will without scruple, fear or remorse

Breach with Rome. During the first twenty years of Henry's reign Parliament had been summoned only when the king was in want of money The wealth amassed by Henry VII had so far nearly sufficed even for his son's extravagance, and appeals for money had been rarely necessary Thus, Parliament being so seldom called, Wolsey had accustomed the country to government without it Now it was to be in constant session, to endorse Henry's policy The reserves were exhausted, but the supplies to be asked for were not to be drawn from the pockets of laymen, but from the spoliation of the Church The long-established payments to Rome were to go instead to the royal treasury An enormous fine was levied for a technical breach of the law, in which the king as well as the Church as a body had shared. The clergy were no longer allowed to legislate, and all appeals to Rome were forbidden The Pope, Clement VII, remained obdurate, and Convocation declared that the king was the head of the Church

A new archbishop was appointed, Thomas Cranmer, who, presiding over an English ecclesiastical court, pronounced the marriage with Catherine invalid from the beginning Thus, automatically, though the Pope retorted a year later by officially pronouncing it valid, Catherine's daughter Mary became illegitimate, and the breach with Rome was complete Henry married Anne Boleyn Cromwell, as the "vicar (lieutenant) general" of the head of the Church, carried out a visitation of the monasteries, the inmates of which continued to be the Pope's loyal supporters, and whose wealth was in many instances vast. The report of this was held to warrant the dissolution of a great

number of the smaller foundations. The north of England rose in protest ; the insurgents (the Pilgrimage of Grace) were induced by fair words to disperse ; then savage vengeance was taken, and a Council of the North was established to keep the people of those parts in order.

During the latter years of his reign Henry was more despotic than ever. Parliaments were seldom called. The spoliation of the Church included hospitals, colleges and guilds. The larger monasteries met with the same fate as the lesser before them—the confiscation of their wealth, which enriched the Treasury, and of their estates, which were often sold. The purchasers formed a new landed gentry, who had no traditional connexion with their new estates and tenantry, but had a fixed determination not to part with what they had gained. The great act of spoliation was accomplished. In this Henry was unscrupulously abetted by Cromwell, whose aim it was to erect an absolute monarchy, and thereby secure his own high position and enrich not only his master but himself.

Downfall of Cromwell. In 1536 Henry had tired of Anne Boleyn, and on a series of monstrous charges he had her tried and beheaded. Probably her unpardonable crime was that her only child was a daughter and not a son—the daughter who was to become famous as Queen Elizabeth, but who was now pronounced illegitimate. Then Henry married a third wife, Jane Seymour, who died after giving birth to a son, the indisputable heir to the throne. Cromwell had procured from Parliament a new Treasons Act, which practically made the king absolute. He now wished Henry to consummate the battle with the Papacy by alliance with the German states which had adopted Protestantism ; to that end he suggested a fourth bride, Anne of Cleves, for his master. Henry, pleased with a portrait painted of the German princess by Holbein, agreed, but on her arrival found her so unattractive that he discovered technical grounds for repudiating the marriage. Cromwell was denounced for treason. A bill of attainder was rapidly passed by both Houses of Parliament and assented to by the king. Cromwell was sent to the scaffold without being even heard in his own defence—condemned under his own treason law (1540). During the remainder of Henry's reign there was no further advance towards Protestantism. In spite of his fifteen years of plunder and his vast inherited wealth, he finished with the financial trick of a

debased system of coinage—a means by which he could pay debts by issuing coins at a nominal value greater than that of the metal composing them. He was driven to this desperate expedient by the expenses incurred in aggressive wars with Scotland and France in which England was engaged between the years 1544-46

Prayer-book of Edward VI. Henry had been expressly authorized to fix the succession by will; after Edward he *nominated Catherine of Aragon's daughter, Mary, and after* her Anne Boleyn's daughter Elizabeth. Edward had been brought up in a strictly Protestant atmosphere; at the moment of Henry's death (1547) the Howards, the lay leaders of the Catholic party, were in disgrace—owing to the fall and execution of the fifth queen, Catherine Howard—and the advanced party, headed by Somerset, the young king's uncle, were able to seize control Somerset and Thomas Cranmer, Archbishop of Canterbury—both idealists with little sense of the practical—pushed forward the Reformers' programme, and a revised prayer-book was issued in 1549. Somerset was ousted from power by his rival Northumberland, who joined the extreme Reformers. Edward had now come to regard all defection from Protestant orthodoxy as criminal. A second prayer-book was issued, accompanied by an Act of Uniformity, imposing its acceptance under severe penalties on both clergy and laity. England was to be firmly Protestantized. But a religious system built up solely on the will of the king was hardly likely to survive him. Edward VI, a minor still, died in 1553. Under Henry's will the heir to the throne was Mary, a zealous Roman Catholic. In fear of the results of her accession, Northumberland had persuaded Edward to make another will leaving the crown to his cousin, Lady Jane Grey, a fervent and sincere Protestant, who was proclaimed queen But so hated was Northumberland that public opinion was solid on Mary's side, and the people would have nothing to do with a claimant advanced by him. The revolt was easily crushed, and Jane was sent to the Tower. Then another revolt was raised on behalf of Elizabeth which was also crushed, and Jane and her young husband, Dudley, were sent to the block and Elizabeth to the Tower. No evidence of her complicity could be found, but she remained virtually a suspected prisoner for the rest of the reign.

Mary's Restoration of Catholicism. In 1554 Mary married Philip, the crown prince of Spain, who received the title of

king, and the names of Philip and Mary appeared together on state documents and on the coins. Before a year had passed the queen was begging the Pope's pardon for the sin of breaking away from Rome, and craving reconciliation. The new Parliament called after the marriage proved subservient to her wishes and re-enacted the old penal laws against heresy, but would not surrender the monastic lands

A persecution of Protestants then set in, in which some three hundred persons—including Cranmer and several bishops, but no laymen of consequence—were sent to the stake. The effect was the precise opposite of what Mary had hoped and believed it would be. Persecution by fines, imprisonment, even by death not made conspicuous, might have served her purpose; but the martyrdom by fire created a revulsion of sentiment in the hearts of the people. Though considerable numbers remained steadfast in the old faith through good and ill, the fires of Smithfield made England a Protestant country through all the wars of religion from which Europe was to suffer for a century to come. Philip was, mistakenly, held responsible; but he involved his wife in a French war, which resulted in the loss of Calais, two hundred years after its first capture. A deep hatred of Spain was implanted in the English people. In 1558 Mary died, a defeated and sorrowful woman. Not only did Protestantism flourish, but she had no child or heir to carry on her zealous work for the Church of Rome. Elizabeth, for whom Protestantism was not a religious creed but a political necessity, became queen of England.

LESSON 10

England in the Elizabethan Age

(See plates 37 and 38)

THE reign of Elizabeth (1558–1603) was for England an age of greatly advanced civilization for the wealthier classes and increased prosperity for all except the poorest. The period of transition between the feudalism of the Middle Ages and the Reformation had been one of disorder and consequent trade stagnation The spread of vagrancy and pauperism had been hardly checked by the terrible laws of Henry VIII. The currency had been utterly disorganized by the issues of

debased coinage Elizabeth and her Council sent out a proclamation in 1560 explaining the evils of this currency and their determination to call in the whole of it and issue a new coinage. This effected, the resultant sound currency ensured a revival of industry Under the wise administration of William Cecil (who became Lord Burghley), leakage of State funds and waste disappeared The importation of manufactured goods and the export of raw materials (with the exception of wool) were discouraged

Great industries were established by granting monopolies to those who engaged in them Wages were to be fixed annually for each district for every trade and employers could pay neither more nor less than the settled sums to labourers Hours were about nine and a half a day in summer, and eight and a half in winter Companies authorized by the Crown took the place of the old guilds Protestant refugees from Flanders and France, who were skilled craftsmen, were encouraged to settle in one or two trade centres and introduced their methods of manufacture of paper, silk, and other commodities So successful as teachers were these foreign workers that other towns received licences for settlers In addition to silk weaving, the lace-making industry was introduced in many districts by French Huguenots

Voyages to the New World. English commerce was also advancing with the decay of the old-time control over trade exercised by the German Hansa, or league of commercial cities, and with the growing venturesomeness of English merchants and mariners, who were endeavouring to extort for themselves a share in the Spanish monopoly of that New World across the Atlantic which Columbus had discovered for Spain in 1492. Year by year the England which, at least since Henry's death, had been sinking lower and lower in the eyes of Europe, was being consolidated once more—prosperous, well-ordered, wealthy, contented and—adventurous. Of the gentlemen adventurers of this age the two most famous are Sir Humphrey Gilbert and his half-brother, Sir Walter Raleigh (c. 1552–1618) The former is noted for his quest of the north-west passage ; he founded the first English colony in America The latter was poet and historian, as well as explorer Desire for extension of his sovereign's wealth led him in 1595 to seek El Dorado in Orinoco. He could not, however, persuade Elizabeth to take his enterprise seriously, and he was, through delay, forestalled by the Spaniards.

Personality of the Queen. Elizabeth came to the throne determined to rule over Church and State as had her father, Henry VIII. A new patriotism appeared, which was in itself a religion—an extraordinary personal loyalty to the queen This loyalty had a glowing social quality, comprising both Catholics and Protestants It dwarfed all other loyalties. Though to Catholics the legitimate heir was unquestionably Mary Queen of Scots, great-niece of Henry VIII and wife of the French dauphin, the bulk of English Catholics were personally loyal to Elizabeth. Since France was Spain's rival, Philip, now king of Spain, was forced to prefer Elizabeth to Mary as queen of England. So far as foreign intervention was concerned, Elizabeth was secured for years to come by the rivalry between France and Spain. Reconciliation with the Papacy would involve acknowledgement of her own illegitimacy, and was out of the question Oppression of Catholics would drive them to a preference at least for Mary. So she worked out a religious settlement which, though definitely Protestant, could be acquiesced in by all but the more rigid Catholics and the most extreme Protestants, and which was expressed in a new prayer-book, a new Act of Uniformity, and the thirty-nine Articles. Between them, these imposed a uniformity of practice that was not to be transgressed, while permitting a very wide latitude of personal opinion, and so satisfying the great majority of her subjects.

Mary Queen of Scots. Ten years after her accession Elizabeth held captive the only person who could possibly be made a figurehead for rebellion—Mary Stewart. Mary had not attempted to claim the English throne. The dauphin succeeded in France, but almost immediately died, and Mary, who had passed the whole of her girlhood in France, returned to Scotland, a widow at eighteen. There Protestantism in its most rigid and joyless form was already completely predominant; the government was in the hands of the nobles who called themselves the Lords of the Congregation and of the Calvinistic ministers of religion, headed respectively by Mary's half-brother Moray and John Knox. Struggling for independence, she married her cousin Lord Darnley, a youth with no merits whatever except his good looks. The marriage was a disastrous failure. Darnley joined some of the nobles in a conspiracy to murder the one man whom she trusted—her Italian secretary, Rizzio. A year later Darnley himself was murdered. The queen was carried off by Bothwell,

the man whom everyone knew to be the murderer, and—married him, thereby convincing the world of her own complicity. The nobles rose, drove Bothwell from the country, and carried Mary a prisoner to Lochleven, where she was forced to abdicate in favour of her infant son James. She escaped from her prison, but the few followers who rallied to her were defeated at Langside, and by hard riding she crossed the border to throw herself on the mercy of Elizabeth (1568)

For eighteen years Mary remained a captive in successive English prisons, a perpetual figurehead for plots which were detected, watched till the moment arrived for exploding them, and then duly exploded. Mary's character was blackened in the eyes of the world by the publication of the charges brought against her, while she was denied all opportunity of answering them and was never brought to trial. While she lived she was a constant danger but a useful hostage. Only when war with Spain could no longer be deferred her life ceased to be useful, and Elizabeth consented to her death after a " trial." The problem of her guilt or innocence was left for ever insoluble.

Relations with Spain. Throughout those years Elizabeth, her ministers, and the nation were preparing for the conflict with Spain which the queen was resolved to postpone till the last possible moment, whereas Philip was waiting only to strike and crush at his own time—which would be when the Netherlands were completely subjugated. Elizabeth's calculated vacillations, her diplomatic juggleries, the astute trickeries with which she befogged friends and foes alike, and repeatedly evaded war when further evasion seemed impossible, are a most interesting study but too intricate to be pursued here. Philip's agents were palpably mixed up with one after another of the plots in England; his subjects came to the help of rebels in Ireland and English volunteers joined Philip's rebels in the Netherlands. In 1572 Francis Drake raided the Spanish Main, and again in 1578 when on his epoch-making voyage round the world. But still no declaration of war followed till Philip's seizure of the English ships in the Spanish ports put an end to the peace that was no peace. Troops were sent officially to the Netherlands, and Mary was at long last beheaded at Fotheringay (1587). Then in the same year Drake was let loose once again, and destroyed the fleet in Cadiz harbour, thus delaying the sailing of Philip's great punitive expedition for a twelve-month.

Defeat of the Armada. It sailed in 1588, passed up the Channel where it was hammered and partly crippled by the English gunnery, but still in solid formation till it reached Calais Roads, from which it was driven out in a midnight panic by fireships. In the morning it lay scattered along the Gravelines coast at the mercy of the English, who fell upon the rear and were destroying it piecemeal when a furious squall arose which stopped the fighting. When the squall cleared, the already shattered Armada was driving north past the east coast in wild flight, to be pursued by the English as long as ammunition lasted—that of the Spaniards was already exhausted. The winds, the waves, and the rock-bound coasts did the rest, and it was only a crippled remnant that ever succeeded in making a Spanish port. *Dominus flavit et dissipati sunt* But the mariners had done their work first. The new English and Dutch tactics—learnt in the stormy waters of the north—of relying upon gunnery, seamanship, and the manoeuvring of sailing ships, had decisively triumphed over the old tactics of mass formation derived from the oar-driven war-galleys on the smoother waters of the Mediterranean. The Spanish dominion of the seas was gone for ever, though more than another century passed before England had won definite supremacy.

With the destruction of the Armada, Spain ceased—though Philip knew it not—to be a menace. He went on building armadas which came to nothing; and still the maritime war with England went on, the English preying upon Spanish and Portuguese commerce on the Atlantic and Indian oceans, while the deliberate policy of the queen forbade the delivery of decisively crushing blows, since France must not be left without a continental rival. Apart from the war, and from the outburst of literary glory in Shakespeare and his contemporaries, which is the greatest of the brilliant achievements of Elizabeth's reign, her last years were mainly enmeshed in the intrigues which, when she died in 1603, set the legitimate heir of the Tudors, the Scots king James VI, the son of Mary Stewart, upon the English throne, uniting under one crown the two kingdoms between which a chronic hostility had prevailed for three hundred years.

For the further study of the Elizabethan era, the student may be recommended to read Creighton's "Age of Elizabeth," and "England under the Tudors," A. D. Innes.

LESSON 11

When England and Scotland became Great Britain

(See plates 38 and 39)

JAMES VI, king of Scots, succeeded Elizabeth on the English throne by unchallengeable hereditary right. There was no legitimate descendant of Henry VIII, but James was great-grandson of Henry VII's elder daughter Margaret by her first marriage, and in her, as in all Henry VII's children, the claims of the rival houses of Lancaster and York were united. Like the Plantagenets, the Scots royal family were descended from Alfred the Great. A political motive, not a legal title, was the only pretext for any plots against the crown that occurred during his reign. His accession united under one crown two kingdoms which had, and continued to have, different laws, different officers, different administrative systems, and a tradition of chronic hostility to each other extending over three hundred years. Both countries were Protestant: but the official episcopalian brand of Protestantism in England was not easily reconcilable with the Calvinist brand prevalent in Scotland. Calvin had held that the State was subordinate to the Church, whereas in England, since the Reformation, the Church was subject to the State. After the defeat of the Armada, however, the circumstances which had led to the Tudor dictatorship were disappearing. England at the end of Elizabeth's reign was a strong, united country. She, with Tudor wisdom, had used her powers discreetly and had met with personal approbation. In politics and religion ideas of official government were gaining ground. The Divine Right of royalty, so fervently adhered to by James and his son Charles I, was already being displaced by the idea of a constitutional royalty dependent on the will of the people.

One point of advantage there was in the union between the two kingdoms; they could not be at war with each other unless one or other was in rebellion against the common king, nor could they simultaneously pursue antagonistic foreign policies. Yet it was not fifty years since Scotland had broken off her old

relations of alliance, maintained for two and a half centuries, with England's other most constant foe, France.

Relations of England and Scotland. During those centuries since Robert Bruce, Edward III had effected a temporary revival of the English suzerainty by setting Edward Balliol, son of John, on the throne by force of arms, but Edward in turn had been driven out when the project of the French war was developing in the English king's mind. In the year of Crécy the young Scots king, David Bruce, invaded England, was taken prisoner, and released only on promise of a ransom, which was never paid

Early in the reign of Richard II, the king and his uncle John of Lancaster found in border raids an excuse for ravaging south Scotland. Henry IV's quarrel with the Percies was concerned with the ransom of Scottish nobles taken in a great fight on the border. Henry IV captured the Scottish crown prince in time of peace, on the high seas, a few weeks before his father's death, which made him James I of Scotland, and the young king was held a prisoner—or, at best, a hostage—in England for twenty years, while Scots volunteers were fighting against the English in France For the rest of the 15th century the fighting between English and Scots was not on a large scale Then Henry VII tried to set relations on a better footing by marrying his elder daughter Margaret to James IV, yet ten years later, while Henry VIII was fighting with France in Flanders, James invaded England, to perish at Flodden

Throughout his reign Henry made repeated attempts to capture James V, perhaps intending for him the fate which Mary Queen of Scots met with at the hands of Elizabeth. Edward I's dream of a united kingdom was indeed a crying necessity for the greater prosperity of both countries, as most of the abler statesmen in both had long recognized—if it could be effected without subordinating the interests of the smaller and poorer country to those of the larger and richer. But now the Scots were reconciled to the union of crowns by the fact that, as it was a king of Scots who was becoming king of England by hereditary right, not an English king who was being forced upon Scotland, that country should at least be secure of fair play in the partnership.

But there was another side to the picture. England, in spite of recurring civil discords and dynastic conflicts, had been for centuries the best governed of European countries; the rule of

law and order had been more consistently prevalent there than elsewhere Serfdom had practically disappeared, life and limb and property were more secure, justice was more even-handedly administered , and England was unique in having enjoyed for a long time the possession of a Parliament representative of the Commons, whose assent—though it had no direct control over the administration—was necessary before any new law could be made, any old law abrogated, or any new tax levied—a Parliament which did not, indeed, govern, but whose goodwill no government could afford to dispense with continuously

Very different was the case with Scotland. Of the eleven monarchs who had come to the throne since the death of Robert Bruce all but two had been minors on accession, and only two more had lived beyond forty, except Queen Mary, who was deposed at twenty-six

Strong central government had only been possible at intervals; a turbulent and factious baronage had never been long held under control and what passed for a Parliament either was dominated by the barons with the strongest armed following at the moment, or handed over its functions to a committee of the dominant faction England was the most, and Scotland the least, law-abiding of countries James had spent his whole life in winning by craft more control than any but two or three of his ten predecessors had ever exercised, and his conception of the rights and duties of kingship was based entirely on his experience as king of Scots, in which there was no counterpart to the new national spirit arising in England

Theory of Divine Right. In his view the law should be enforced on and obeyed by the subjects, but the king was by right divine above the law , the rights of Parliament were favours granted by the king's grace, and might be overridden at the king's will—though a wholesome terror of armed rebellion set the limit he would refrain from passing in carrying his theory into practice Hence it was inevitable that there would sooner or later be collisions between the new Scots king and the English Parliament, which even under Elizabeth had been restive whenever it scented royal encroachments on its own rights.

The strength of Parliament lay in its power to refuse supplies —in other words, to make the voting of supplies conditional on the remedying of grievances. With a government which it trusted and a policy which appealed to it, supplies were always

forthcoming. With James on the throne, it neither understood nor trusted his policy. The country was always ready for war with Spain, and its dread of Roman Catholicism was raised to fever heat by the desperate "Gunpowder Plot" of a few fanatics for blowing up king, ministers and Parliament, in the third year of the reign. James wanted alliance with Spain at almost any price, without realizing that Spain's price was, in effect, the restoration of the Roman Church in England—not merely the toleration which he himself desired, but which the progressive Puritanism of a large number of his subjects abominated. If he called Parliament to vote supplies, it aired its grievances and criticized policy instead; and the king, in constant need of money, fell back upon methods of raising it which were denounced in Parliament as illegal but were declared by the judges to be within the royal prerogative. The tension between crown and Parliament was increased by the arrogance, incompetence and profligacy of the favourite George Villiers, whom James had made duke of Buckingham and intimate companion and confidant of the heir to the throne. James had always evaded an irreparable rupture, not without some humiliation. He died in 1625, leaving Charles I the still unsolved problem and—Buckingham.

Birth of the British Empire. Such honours as belong to the reign of James I and VI were legacies of the last reign; half the literature which we call Elizabethan was actually produced after his accession, and it was Elizabeth's mariners who had been pioneers of the maritime and oversea empire which had its actual beginning under James. The East India Company, incorporated in 1600, leased its first trading station at Surat in 1609. Sir Walter Raleigh had striven in vain to create the nucleus of a Greater England beyond the Atlantic; in 1607—while he was eating his heart out, a prisoner in the Tower, where he was kept until 1616—a settlement was made by the Virginia Company which survived all vicissitudes, and in 1620 the Pilgrim Fathers planted the first Puritan colony—also with the assent of James—farther north at New Plymouth. Out of Surat grew in fullness of time the British Dominion in India, and out of those two colonies sprang the British colonial empire and the United States of America. When Elizabeth died, England was not in possession of one yard of soil outside the British Isles; in the days of her successor, the first hereditary king of England, Scotland and Ireland, the British Empire was born.

LESSON 12

Charles the First's Long Duel with Parliament

(See plate 40)

When James died (1625) Europe was already in the throes of the Thirty Years' War, primarily a great German civil war within the Empire, but one in which every European state was sooner or later involved. England and France were at this time both on the brink of intervention, and the disastrous failure of an English expedition, in support of the Elector Palatine, for which the blame was laid on Buckingham, was the last event of the reign of James. England had just broken with Spain, and Charles was on the point of marrying the French king's sister, Henrietta Maria. Buckingham was at the height of his unpopularity with the people and of his favour with the king, who was badly in want of money for the war, while the country was in no mind to provide money merely that it might be mis-spent by Buckingham. So when the inevitable Parliament was called, it voted, for one year and no more, a tax upon imports known as "tonnage and poundage," which had for two centuries been granted to successive kings for life, though it was not one of the "ancient customs" to which all kings were entitled by statute. In Charles's eyes, this limitation was a breach of royal rights established by unbroken custom. When Parliament followed this up by, in effect, demanding the dismissal of Buckingham, and went on to denounce the favour shown by Charles to members of the High Church party, whom they regarded as little better than Papists, Charles dissolved the Parliament, though it had voted only a fraction of the supplies he had demanded.

Genesis of the Struggle. James I had made free use of non-statutory methods for raising money. In the case of impositions or increased customs duties, he had the sanction of common law. Monopolies, benevolences, distraint of knighthood, commissions of array, all of which had been employed in moderation by the Tudors, were made the instruments of tyranny by James and Charles. Neither king denied to Parliament the power of making statutes or of granting supplies, but they did deny it the exclusive right; they nullified the power that it had by levying impositions

and loans and by issuing proclamations. In Charles's opinion it was the duty of the House of Commons to grant a yearly subsidy, and refusal to do so was obstructive, unconstitutional, and rebellious. Unfortunately, he believed also that he could outwit Parliament by appearing to yield, afterwards returning to the exercise of arbitrary power; it is probable that he sincerely held himself unfettered by promises obtained under compulsion, which bound him to actions not in accordance with the office of king as he understood it

A new Parliament was called, attacked Buckingham as a preliminary to discussing supplies, and was dissolved. Nearly two years passed before a third was summoned in 1628. Meanwhile Charles, with the support of the judges, had been collecting tonnage and poundage as if a parliamentary grant were unnecessary for all direct taxation; he had tried to levy a compulsory or forced loan, dismissed his chief justice for denouncing it as illegal, and imprisoned recalcitrants who refused to pay, without bringing any specific charge, by royal prerogative. Buckingham had intervened against the French government on behalf of the Huguenots at La Rochelle had personally led an expedition thither with disastrous results, and was burning to avenge his defeat.

The Petition of Right. The third Parliament was seething with anger when it met, and it proceeded to pass in both houses the Petition of Right, which required the king to govern according to law—quite incompatible with the Stuart idea of Divine Right—and forbade the levying of any taxes or loans without consent of Parliament. The petition is the first important statutory restriction of the powers of the crown since 1485. Charles, putting on it an interpretation which was not the Parliament's, yielded assent after some resistance. Parliament returned to the attack on Buckingham and the High Church appointments, and was forthwith prorogued (not yet dissolved). After this the constitutional debate takes on more and more the aspect of a religious controversy.

Thomas Wentworth, hitherto a leader of the Commons, deserted his old colleagues and joined the king—a far more able upholder of his rights than Buckingham, who was assassinated by a madman a few days later.

The same Parliament met again in January (1629), fell at once to denouncing the continued taxation and the king's ecclesiastical

policy, and was dissolved. For the next eleven years Charles ruled without summoning a Parliament at all. As by proclamation he was able to make new laws and alter old ones, and as he continued to collect tonnage and poundage together with imposts, and enacted the customs dues and other sources of revenue in spite of the Petition of Right, it seemed at first as though he could be independent of Parliament, the very name of which he hated

Hampden and 'Ship Money.' While the ingenuity of lawyers revived long obsolete but technically legal methods of scraping some revenue together by prerogative, the most famous of these measures, known as "ship money," was at best, in the form adopted, of doubtful legality. In 1634, though England had withdrawn from the Thirty Years' War, the seaports and maritime counties were required to furnish ships for defence of the commerce of the country against the Dutch and French navies; shortly afterwards the king demanded from the inland counties money to compound for further equipment of the fleet. The demand was in defianc of the Petition of Right and struck at the very existence of Parliament. The king was unwilling to meet his Commons in case his cherished ecclesiastical policy was threatened, and he submitted the legality of his case to the judges, who laid it down that the king, under the Great Seal of England, can compel his subjects, when the country is in danger, to supply means for defence—the king to be sole judge of that danger. In 1637 John Hampden, a squire of Buckinghamshire, refused to pay, and the question was thrashed out by the twelve judges of the Exchequer. Seven decided for the king and five were for Hampden; only two declared the tax illegal.

So vital was this case to the position of Parliament that the Long Parliament passed a special act declaring the judgement void, to which the king gave assent in 1641. It declared the ship money writs to be illegal and condemned the king's practice of obtaining an outside legal opinion. Statute law henceforth was not to be the servant of common law

During the eleven years between the meetings of Parliament, however, popular resistance to the government measures continued to be suppressed by the three arbitrary courts which were indeed legal, having been constituted by Act of Parliament under the Tudors—the Courts of Star Chamber, High Commission, and the Council of the North—but had the power of imposing

arbitrary penalties. The second, an ecclesiastical court, was presided over by Archbishop Laud, and the third by Wentworth, who was, in effect, viceroy in the northern counties until he was transferred to Ireland, where he ruled with an iron hand, but with unprecedented success.

Scottish National Covenant. During those years Charles was unconsciously sowing the wind in England, but it was in Scotland that he began to reap the whirlwind. He wished to impose upon the fervently Presbyterian Scots the prelatical English Church system, which to most of them was but disguised Papistry Consequently, without legal machinery or authority, a National Covenant was drawn up and signed by high and low, pledging the signatories to loyalty to the crown and resistance to all religious innovations not sanctioned by the General Assembly of the Kirk and by the Scots Parliament—the English Parliament having, of course, no authority north of the border. When the General Assembly was elected, it practically assumed the sovereign authority, with popular assent. The king had no forces in Scotland with which to compel obedience. He threatened to do so with troops levied in England. The Scots organized an army of their own and marched to the border (1639). A very unreal attempt at a compromise broke down.

Wentworth, summoned from Ireland and ill-informed as to public feeling in England, advised the calling of Parliament and what he took to be the consequent easy suppression of the Scots. In April the Short Parliament met, only to be dissolved (against the advice of Wentworth, now earl of Strafford) after three weeks. The Scots marched into England, not, as they said, to make war but to claim their national rights The king, finding himself helpless, promised to accede to their demands; and at the same time he summoned a new Parliament, by the advice of Strafford's jealous enemies, the court party, who knew, as Strafford knew himself, that his destruction, as the one strong man on whom Charles could lean, would be its first aim.

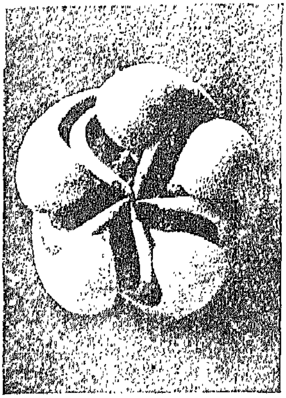
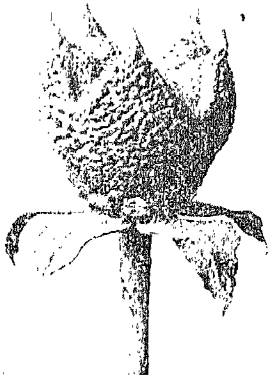
Work of the Long Parliament. In November the Long Parliament met, and proceeded forthwith to the impeachment and arrest of Strafford. Soon, however, it was clear that the charge of treason must break down; for the legal process of impeachment, therefore, a bill of attainder was substituted, passed by both houses, and presented to the king. There was no law under which Strafford could be doomed to death, but an Act of the

king in Parliament would make one for the occasion.' Charles did not dare to refuse ; he signed the Act, sacrificed his champion to the popular hatred and the jealousy of his rivals, and thereby sealed his own doom. Strafford was beheaded in May (1641).

From the moment of Strafford's arrest Charles had been powerless—at first, in the face of a virtually unanimous Parliament. Bill after bill was passed by both houses to which he was forced to give the royal assent—forbidding the extended prorogation of Parliament, or its dissolution without its own consent ; abolishing the arbitrary courts which had been the instruments of oppression ; abolishing all the methods, whether technically legal or not, by which Charles had raised money without consent of Parliament. But a rift on the religious question, which grew and grew, revealed itself when the Puritans in the Commons introduced and passed a Bill for the total abolition of episcopacy which never reached the Lords. To resist religious oppression was one thing, to attack the Church of England itself was another. The moderates, repelled by Puritan fanaticism, began to range themselves on the king's side. Then there arose an anti-Protestant insurrection in Ireland, which wild rumours attributed to the king's machinations. An armed force was needed in Ireland ; but if it were under the king's control, would he not use it for the overthrow of English liberties ? The Commons prepared a militia bill which would give the control not to the king, but to themselves ; and then they passed, against fierce opposition and by a majority of no more than eleven votes, a long resolution called the Grand Remonstrance, which was a detailed indictment of the king's government—and including his foreign policy—from the beginning. The moderates had now been converted into steadfast royalists by the action of the extremists.

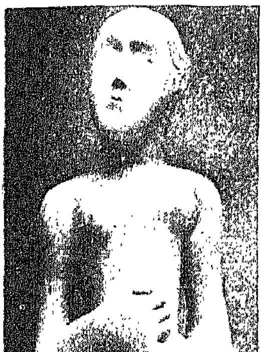
Charles saw his opportunity but misjudged the strength of his supporters. Elated by the reaction, he attempted a *coup d'état*, coming down to the House with a body of troops to arrest five leaders of the opposition. They had warning, and were not there. The blow had failed, but the action set a spark to the flame of rebellion (Jan. 1642). A week later Charles was on his way to the north, and by the end of August the country was in the throes of the Great Civil War.

Our Course in British History is continued in Volume 5.

GEOMETRICAL FORMS IN NATURE. The young fruit of the common rue with calyx (right) and the opened seed capsule of the nettle (left), selected from a series of enlarged photographs from Nature, dispel the idea of a wild, ragged and haphazard plant life. *They reveal, in common* with minute animal organisms, definite shapes of intentional order and logical development, from which the artist derives basic forms to be reassembled in his work.

Photographs from Prof. Karl Blossfeldt's "Art Forms in Nature," by courtesy of Messrs. A. Zwemmer




MODERN EXAMPLES OF ESSENTIAL SCULPTURE. These two direct carvings *from a block of Ancaster stone (left), and from Cumberland alabaster (right),* are organizations of form as symbols of life. "Girl," by Henry Moore, is non-representational of any particular girl; "Mother and Child," by Barbara Hepworth, makes no attempt at portraiture, but seeks to symbolize in sculpture a permanent and universal idea of motherhood. ART AND ARCHITECTURE 24

Courtesy of Messrs. A. Zwemmer

ARCHITECTURAL SCULPTURE IN BRICK. This relief is one of a series carved by Eric Kennington in brick on the brick façade of the Shakespeare Memorial Theatre at Stratford-upon-Avon. The figures are over life-size and were executed in position without preliminary clay models. ART AND ARCHITECTURE 24

Courtesy of "The Architectural Review"

STONE CARVED SYMBOL OF NIGHT. Jacob *Epstein* in executing the sculptures of Day and Night (the latter shown above) for the Underground Building, Westminster, carved them directly in stone. They are thus interesting contributions to modern architectural sculpture. His bronzes, though magnificent, are not modern, but are his individual development of the Romantic sculpture of the 19th century. ART AND ARCHITECTURE 24

Courtesy of London Passenger Transport Board

LESSON 27

Chromium Group of Metals

THE elements chromium, molybdenum, tungsten and uranium bear a certain chemical resemblance to sulphur, and are, therefore, included in group 6 of the periodic table (Vol. 1, p. 160). Thus they form oxides of the type CrO_3, which, like SO_3, are acidic in character and on solution in water give rise to acids such as H_2CrO_4 (cf. H_2SO_4); the salts of these, acids, e.g. K_2CrO_4, are in general isomorphous with—that is, have the same crystalline form as—sulphates. In spite of this resemblance to sulphur, however, the elements have very definitely metallic properties; thus they all form trivalent salts of the type $Cr_2(SO_4)_3$, which in solution ionize to give positively charged metallic ions.

Of these metals, chromium is by far the most abundant; it occurs principally as chromite or chrome iron ore—$Cr_2O_3.FeO$—which is found in South Africa, Russia, the United States and India. Because of its inertness towards oxygen, chromium has recently found an extensive use for plating metals and in the manufacture of rustless steels. The methods of extraction of the metal are based on these two applications; the ore is ground to a fine powder, mixed with lime and potassium carbonate and roasted. The lime is added merely to keep the mass porous, so that the oxygen of the air can bring about the necessary oxidation; potassium chromate is produced according to the equation:

$$4FeO.Cr_2O_3 + 8K_2CO_3 + 7O_2 \longrightarrow 8K_2CrO_4 + 2Fe_2O_3 + 8CO_2:$$

and is extracted from the residual mass by washing with water. On treatment with sulphuric acid, the chromate is converted into the dichromate ($K_2Cr_2O_7$), and the resulting solution is then used for electro-plating.

Metallic chromium, as required for rustless steels, etc., is obtained by the reduction of Cr_2O_3 by the "thermite" or Goldschmidt process. The oxide is mixed with powdered aluminium and a small amount of barium peroxide, and the mass ignited

in a large refractory clay crucible by means of a piece of magnesium wire. In the intense heat of oxidation of the aluminium, the chromic oxide is reduced to the metal, which melts and collects at the bottom of the crucible. If the crude chromite ore is taken, the iron present forms a slag with the alumina and is removed from the surface as a scum ; if pure Cr_2O_3 is required, it is obtained by the hydrolysis of potassium chromite, prepared by heating the dichromate with a reducing agent.

Chromium is an extremely hard, greyish white metal ; its melting point is about 1920° C., and it is almost completely unreactive to moist air or oxygen. It dissolves fairly readily in warm hydrochloric and sulphuric acids, forming chromous chloride and sulphate and liberating hydrogen and sulphur dioxide respectively. When chromium is added to steel an extremely hard and tough alloy is obtained ; for this reason chrome steels are used for armour plating, high speed tools, safes, crushing mills, stainless cutlery, etc these alloys, some of which contain as much as 50% of chromium can be prepared directly from chrome iron ores by the thermite process or by reduction with carbon in an electric furnace.

Chromium is also used in plating the bright parts of motor-cars, bath-taps, and other metal articles ; the plating is usually carried out in a glass-lined tank with a lead anode and a solution of potassium dichromate in dilute sulphuric acid as the electrolyte.

Compounds of Chromium. Chromium exhibits three valencies —2, 3 and 6—and forms three oxides viz. chromous oxide, CrO, chromic oxide or chromium sesquioxide, Cr_2O_3, and chromium trioxide CrO_3 Chromous oxide and hydroxide are distinctly basic and form a well-defined series of comparatively stable salts, which resemble similarly constituted divalent salts, such as $CuCl_2$, $FeCl_2$, and so on. In chromic oxide the basic properties have become very much weaker ; chromic salts such as $CrCl_3$, $Cr_2(SO_4)_3$ tend to hydrolyse in water Moreover, in the presence of a strong base the sesquioxide reacts as an acid to form chromites:

$$2KOH + Cr_2O_3 \rightleftharpoons K_2Cr_2O_4 + H_2O \text{ (potassium chromite)}$$

Chromium trioxide, like sulphur trioxide, is a strongly acidic oxide ; it may be considered to be the anhydride of chromic acid—H_2CrO_4—and reacts with bases to form chromates and dichromates.

Chromous chloride and sulphate are prepared by dissolving the metal in hydrochloric or sulphuric acid, the chloride may also be prepared by heating anhydrous chromic chloride in a stream of hydrogen The anhydrous salt is colourless and dissolves freely in water to form a bright blue solution When this solution is treated with caustic soda in the absence of air, a yellowish precipitate of chromous hydroxide is formed, this is rapidly oxidized in the presence of oxygen to the chromic state

The preparation of chromic oxide—Cr_2O_3—from chromite has been mentioned, it is also prepared by dehydrating chromic hydroxide or by heating ammonium dichromate, which decomposes according to the equation.

$$(NH_4)_2Cr_2O_7 \longrightarrow Cr_2O_3 + N_2 + 4H_2O$$

the oxide is set free as a voluminous green powder, and is used in the manufacture of certain paints and pigments

Chromic hydroxide is precipitated as a greenish-blue jelly when an alkali is added to the solution of a chromic salt. In the presence of a strong base it dissolves to form a chromite. Chromic salts may be prepared in solution by dissolving the oxide or hydroxide in acids, or by reducing chromate or dichromate solutions with a reducing agent such as hydrogen sulphide or sulphur dioxide These solutions may be green or violet in colour, according to the temperature and the concentration—a phenomenon which has been shown to be due to the existence of different complex actions, in which the chromium is associated with molecules of water and also with the acidic element or radical, thus:

$$\underset{\text{green}}{(CrCl_2.4H_2O)^+} + 2H_2O \rightleftharpoons \underset{\text{violet}}{(Cr.6H_2O)^{+++} + 2Cl^-}$$

Chromic sulphate is obtained in the form of violet crystals when chromic hydroxide is dissolved in hot concentrated sulphuric acid and the solution allowed to stand With the sulphates of the alkali metals it forms a series of double salts, which are analogous to the class of compounds known as the alums (*see* Vol 3, p 205). These salts possess a formula similar to that of the alums and are isomorphous with them, e.g. $K_2SO_4.Cr_2(SO_4)_3.24H_2O$; for this reason they are known as the chrome alums The potassium salt—called potassium chrome alum—is prepared by

the reduction of potassium dichromate in the presence of sulphuric acid, thus :

$$K_2Cr_2O_7 + 3SO_2 + H_2SO_4 + 23H_2O \longrightarrow K_2SO_4.Cr_2(SO_4)_3 \; . \; 24H_2O$$

Chromates and Dichromates. Chromium trioxide—CrO_3—is precipitated in the form of scarlet needles when sulphuric acid is added to a concentrated solution of a dichromate The oxide is freely soluble in water, and gives rise to two series of salts, the chromates and the dichromates. The equations for the formation of the potassium salts are written :

$$CrO_3 + 2KOH \longrightarrow \underset{\text{(chromate)}}{K_2CrO_4} + H_2O$$

$$2CrO_3 + 2KOH \longrightarrow \underset{\text{(dichromate)}}{K_2Cr_2O_7} + H_2O$$

Solutions of chromates are yellow and slightly alkaline; dichromate solutions are orange and weakly acid. Chromates are readily converted into dichromates by the addition of an acid, while the addition of an alkali causes the reverse process Both of these substances are powerful oxidizing agents, dichromates being particularly strong. Thus potassium dichromate readily liberates chlorine from hot concentrated hydrochloric acid, bromine from bromides, iodine from iodides, and oxidizes sulphites to sulphates, hydrogen sulphide to free sulphur and ferrous salts to ferric salts. The powerful oxidizing properties of these compounds are due to the readiness with which chromium changes its valence from 6 to 3, according to the equation

$$2CrO_3 \rightleftharpoons Cr_2O_3 + 3O$$

Since, in acid solution, potassium dichromate contains two molecules of CrO_3, it liberates three atoms of oxygen which are available for oxidation. This may be written :

$$K_2Cr_2O_7 \longrightarrow K_2O + Cr_2O_3 + 3O$$

which is the basis of the use of this salt in the titration of ferrous iron. Barium (yellow), lead (yellow), and silver (brick-red) chromates are all insoluble in water, and they are accordingly used as a means of detecting these metals in qualitative analysis.

Molybdenum, Tungsten and Uranium. Molybdenum has found an important use during recent years in the manufacture of alloy steels which are extremely hard and retain their temper even after heating to a high temperature For this reason they are used for high speed cutting tools, rifle barrels, etc The metal is obtained from its oxide either by the Goldschmidt process or by reduction in an electric furnace

The most important salts of molybdenum are the molybdates, obtained by dissolving the trioxide (MoO_3) in alkalis (cf chromates) *Ammonium molybdate* gives with a solution of a phosphate a canary-yellow precipitate of ammonium phosphomolybdate and is used in qualitative analysis for the detection of phosphates

Tungsten occurs as scheelite ($CaWO_4$) and wolframite ($FeWO_4$) the ore is converted into the trioxide (WO_3) by roasting with sodium carbonate and treating the resultant sodium tungstate with an acid The trioxide may then be reduced to the metal in the same manner as molybdenum Tungsten is also widely used in the manufacture of tool steels, and, because of its high melting-point, it is now finding an extremely important use in the *filaments of electric lamps* and amplifying valves as used in wireless

Uranium, not found native, but in pitch-blende, has the greatest atomic weight of all the elements it forms a number of quadrivalent salts—corresponding to the oxide UO_2—and also a number of uranyl salts, produced when the amphoteric trioxide dissolves in acids The radioactive properties exhibited by uranium salts will be discussed in a later Lesson

LESSON 28

Manganese and Iron in Chemistry and Industry

THE metal manganese occurs in group 7 of the periodic table (vol 1, p 160), and might, therefore, be expected to show a chemical resemblance to the halogens, chlorine, bromine and iodine, which are also members of this group Actually this similarity exists only between compounds of the typical group oxide—Mn_2O_7, thus manganese heptoxide—the

anhydride of permanganic acid ($HMnO_4$)—gives rise to a series of salts called permanganates, which are isomorphous with perchlorates (salts of Cl_2O_7 and $HClO_4$). In its lower stages of oxidation, manganese resembles the metals of corresponding valence, for example, manganous sulphate ($MnSO_4$) reacts chemically in a similar manner to zinc sulphate and nickel sulphate

Manganese in Metallurgy. Manganese occurs fairly widely distributed in Nature, usually in the form of pyrolusite (MnO_2). The extraction of the metal from the ore is a matter of some difficulty, and as its use in industry depends largely on the production of an alloy with iron, the crude manganese ore is mixed with iron ores and reduced in a blast furnace in the ordinary way The pure metal can be prepared by the Goldschmidt process.

When alloyed with steel, manganese possesses the remarkable property of destroying its magnetic qualities; steel containing about 12 per cent of manganese—called ferro-manganese—is completely non-magnetic, and is used in the construction of portions of ships which are near the magnetic compass. Manganese steel is also very tough and strong and, unlike unalloyed steel, it does not lose its temper—that is, it does not become hard and brittle—when heated and quenched For this reason it is used for bends and junctions of tram and train rails, which are subject to excessively hard wear. It is also used for making safes and for crushing machinery, and it was employed in the Great War for steel helmets

Oxides and Compounds of Manganese. Manganese forms seven oxides, of which the most important are manganous oxide (MnO) and manganese dioxide (MnO_2). Manganous oxide, prepared in the form of a greyish-green powder by heating the hydroxide or carbonate, is basic in character and reacts with acids to form stable manganous salts. These are pink in colour and, when treated with a solution of a caustic alkali, give a colourless precipitate of manganous hydroxide, which rapidly darkens in the presence of oxygen owing to the formation of the higher oxides Manganese dioxide—dark brown or black in colour—is obtained when a manganous salt is oxidized or when a permanganate is reduced in alkaline solution with hydrogen peroxide or a manganous salt (a method which is used as a means of estimating manganese) The dioxide is practically insoluble in

water, but with strong acids it reacts as a weak base to form unstable quadrivalent salts, which decompose on warming to give a manganous salt and either oxygen or an oxidation product of the acid used (compare the preparation of chlorine). Manganese dioxide acts as a catalyst in many reactions in which oxygen is produced, e.g. in the decomposition of potassium chlorate and also of hydrogen peroxide.

With strong bases, manganese dioxide reacts as a weak acid; when fused with potassium hydroxide or carbonate in the presence of air or of an oxidizing agent, such as potassium nitrate, it forms a dark green mass of potassium manganate, according to the equation:

$$2MnO_2 + 4KOH + O_2 \longrightarrow 2K_2MnO_4 + 2H_2O$$

Manganates, which are salts of the unstable acidic oxide (MnO_3), are stable in the presence of an alkali, but in neutral or acid solution they tend to hydrolyse, forming a black deposit of MnO and a purple solution of permanganate, thus:

$$3K_2MnO_4 + 2H_2O \longrightarrow 2KMnO_4 + MnO_2 + 4KOH$$

Permanganates—salts of the strongly acidic oxide, Mn_2O_7—are prepared by the oxidation of manganates with chlorine or at the anode in electrolysis. The equation in the case of the potassium salt is

$$2K_2MnO_4 + Cl_2 \longrightarrow 2KMnO_4 + 2KCl$$

Potassium permanganate, which crystallizes in the form of dark purple crystals, is a very important compound. Because of the readiness with which it parts with oxygen, it is a powerful oxidizing agent; when heated alone, it decomposes freely at temperatures above 240° C., giving oxygen and MnO_2. In solution it is used in volumetric analysis for the estimation of solutions containing reducing agents such as sulphurous acid, sulphites, ferrous salts, oxalic acid and oxalates. Owing to its intense purple colour and also to the fact that in these reactions it is reduced to colourless manganous salts, no indicator is required in permanganate titrations. As a rule the permanganate is titrated into an *acid solution* (containing sulphuric acid) of the reducing substance; the basis of the reaction is then given by the equation

$$Mn_2O_7 \longrightarrow 2MnO + 5O;$$

that is, 2 molecules of $KMnO_4$ liberate 5 atoms of oxygen for

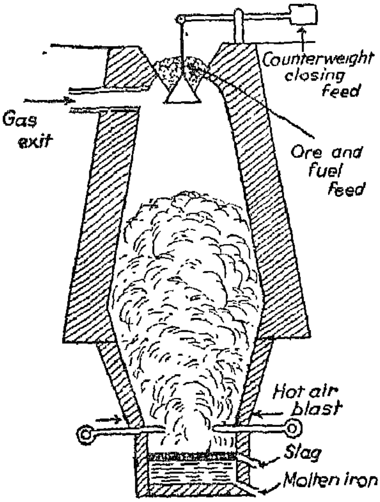
oxidation purposes. In *alkaline solution* the reaction follows another course, manganese dioxide being precipitated according to the equation

$$Mn_2O_7 \longrightarrow 2MnO_2+3O\,;$$

two molecules of permanganate in this case liberate 3 atoms of oxygen.

Potassium permanganate is also largely used for bleaching and for its antiseptic properties

Iron Ores and their Extraction. Iron is by far the most important metal of modern times. In fact the world today may properly be said to be still passing through the "iron age," which had its beginning, so far as the Mediterranean basin is concerned, about 1000 B.C.—about the time of King Solomon. With the exception of aluminium, iron is also the most abundant metal, and because it can be obtained cheaply and with much greater ease than aluminium, it is incomparably the more useful. Moreover, it possesses an enormous range of qualities; by slight differences in treatment and the addition of small amounts of other elements, it can be made hard or soft, brittle or tough, magnetic or non-magnetic, elastic or non-elastic, and so on.



BLAST FURNACE. Fig. 1. Ore, mixed with coke and limestone, is fed in at the top, and molten metal and slag drawn off at the bottom. The high temperature necessary is maintained by means of a hot air blast

Iron is also one of the most important elements of the body; it is an essential constituent of the haemoglobin contained in the red corpuscles, and is present in many of the body proteins and in such foods as shell-fish, eggs, fruit, meat and, particularly, liver. A deficiency of iron in the body leads to a lack of red corpuscles, which may ultimately result in anaemia.

Iron occurs chiefly as oxide, carbonate and sulphide. The

more important oxide ores are magnetite, Fe_3O_4, haematite, Fe_2O_3; and limonite, a hydrated Fe_2O_3. The sulphide, FeS_2, is abundant, but, owing to the difficulty in removing the sulphur, has little commercial value.

The first stage of the extraction of the metal is to mix the ore with coke and limestone and roast it strongly in a blast furnace, as shown in Fig. 1. This is a fire brick tower, generally about 100 feet in height and 25 feet across at its widest part. The ore is fed in at the top and the hot air required for the combustion is led in near the bottom through pipes called "tuyeres." The essential reactions in the furnace are, first, the formation of carbon monoxide from the coke and air-blast at the bottom, and then the reduction of the ore according to the equation

$$Fe_2O_3 + 3CO \longrightarrow 2Fe + 3CO_2$$

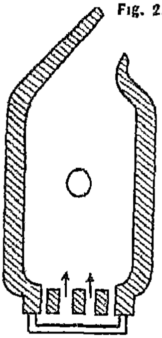


Fig. 2.

The large amount of heat evolved in the formation of the carbon monoxide is sufficient to melt the iron, which collects at the base of the furnace and is run off at intervals into moulds. Iron produced in this way is called "pig" or cast iron. The lime of the limestone combines with impurities such as silica, alumina (clay), and phosphorus to form a liquid slag, and this slag collects on the surface of the molten metal.

Wrought Iron and Steel. Cast iron contains about 3 to 4 per cent of carbon, and is too brittle to be worked easily. Originally it was converted into a much purer form, called wrought iron (containing about 0·2 per cent of carbon) by the laborious "puddling" process, in which most of the carbon was first burnt out in a reverberatory furnace and the remaining impurities removed in the form of slag by hammering the balls of plastic metal with a steam hammer.

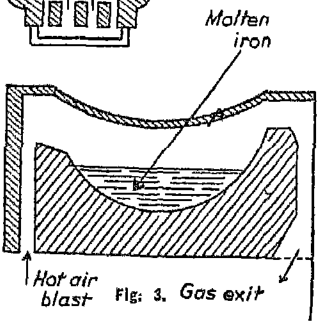


Fig. 3.

PRODUCTION OF STEEL. Fig. 2. Bessemer converter, for the conversion of pig-iron into steel; impurities are burnt off by a blast blown through the molten metal. **Fig. 3.** Siemens open hearth steel furnace.

The wrought iron was then re-heated with the amount of carbon necessary to give a steel of the required texture. This method of making steel gave way in 1855 to the Bessemer process, in which the molten iron from the blast furnace is run straight into a pear-shaped iron vessel called a "converter" (Fig. 2) and the carbon and other impurities are burnt off in the form of oxides by a blast of air blown through the liquid metal. When the impurities are removed a definite amount of cast iron containing carbon and manganese is added to produce steel of the required composition. The converter is often lined with bricks made of lime and magnesium carbonate and the phosphorus which the iron contains is converted into phosphates in the form of a slag, which is sold as fertilizer under the name "basic slag."

Cast iron is sometimes converted into steel by the Siemens open-hearth process, Fig. 3, which is much slower than the Bessemer, but gives a much more uniform product.

Steel contains amounts of carbon varying from 0.2 (mild steel) to 1.5 (hard tool steel) per cent; medium steel, used in structural work, contains about 0.5 per cent. The quality of steel is also considerably affected by the process of tempering; the steel is heated to temperatures up to about 300° C. and cooled very gently. In general, the higher the temperature, the softer is the resulting metal. When steel is heated to redness and cooled suddenly by being plunged into cold water, it becomes so hard that it will scratch glass. The addition of chromium (to form rustless steels), manganese (ferro-manganese) and nickel (nickel steels) is dealt with in the Lessons on these metals.

LESSON 29

Iron Compounds and Associated Metals

IRON dissolves readily in dilute hydrochloric and sulphuric acids, liberating hydrogen and forming the ferrous salt. Concentrated nitric acid renders the metal unreactive, or, as it is called, passive, presumably owing to the formation of a film of oxide, which can be removed by scratching or by the action of a reducing agent.

Iron is not attacked by pure water, but in the presence of moist air containing carbon dioxide it is rapidly corroded with the formation of a loosely attached porous mass of hydrated oxide—

$Fe_2O_3.H_2O$—called iron rust. If the air and water are completely freed from carbon dioxide, no rusting takes place ; the mechanism of the process is by no means clear, but it seems probable that it is due first to the formation of an acid carbonate, which subsequently decomposes to form the hydrated oxide.

Iron forms three oxides : ferrous (FeO), ferric (Fe_2O_3) and *ferroso-ferric* (Fe_3O_4), which is also called magnetic iron oxide or magnetite. Ferrous oxide is fairly strongly basic and gives rise to a well-defined series of salts of which ferrous sulphate is perhaps the most important. It is obtained as light green crystals, sometimes called green vitriol, having the formula $FeSO_4.7H_2O$, when iron is dissolved in dilute sulphuric acid and the resulting solution evaporated. Ferrous sulphate is used as a mordant in the dye industry and also in the manufacture of inks ; when added to the extract of nut galls, which contains tannic acid, it is converted into ferrous tannate. This substance is soluble in water and colourless, but on exposure to air it is oxidized to ferric tannate, which is insoluble in water and forms a fine black precipitate. Gum arabic is usually added to the ink to make it adhesive, and a little blue-black dye to make the writing visible before oxidation.

On exposure to air or on treatment with an oxidizing agent, ferrous salts are converted into ferric salts. Ferric oxide—Fe_2O_3—occurs naturally as haematite, limonite and specular iron ore. It is formed by roasting ferrous sulphate or ferric hydroxide in air. As is to be expected from the increased oxygen content, it is a much weaker base than ferrous oxide, and ferric salts are appreciably hydrolysed in water. Thus, in the case of the chloride, this reaction takes place : $FeCl_3 + 3HOH \rightleftharpoons Fe(OH)_3 + 3HCl$, and can readily be shown by the process of dialysis (*see* Lesson 8, Vol. 1, p. 173). The hydrochloric acid passes through the parchment paper, leaving a colloidal solution of ferric hydroxide. When an alkali is added to the solution of a ferric salt, a flocculent reddish-brown precipitate of ferric hydroxide is formed.

Ferroso-ferric oxide is formed when iron is heated to redness in the presence of air or steam , the reaction in the latter case is written $3Fe + 4H_2O \rightleftharpoons Fe_3O_4 + 4H_2$. This oxide has magnetic properties—hence its name, magnetite—and reacts chemically as if it were a mixed oxide, having the formula $FeO.Fe_2O_3$.

Prussian Blue. When potassium cyanide solution is added to the solution of a ferrous salt, ferrous cyanide is at first precipitated, but this gradually dissolves in excess of the potassium salt, to give finally a solution of potassium ferrocyanide; the equation is written

$$Fe(CN)_2 + 4KCN = K_4Fe(CN)_6.$$

Potassium ferrocyanide is a yellow, crystalline solid, which, unlike potassium cyanide, is non-poisonous. With a solution of a ferric salt, it gives an intense dark blue precipitate, which is called Prussian blue and has the formula $Fe_4(Fe(CN)_6)_3$.

If, on the other hand, potassium cyanide is added in excess to the solution of a ferric salt, potassium ferricyanide is formed. This salt, which crystallizes as red prisms, has the formula $K_3Fe(CN)_6$, when added to a solution of a ferrous salt, potassium ferricyanide gives a dark blue precipitate, which is another form of Prussian blue. These two reactions are used as distinguishing tests for ferrous and ferric iron in solution. A solution of a ferric salt also reacts with a thiocyanate to produce a vivid red colour, a reaction which is used as a means of detecting ferric iron.

Cobalt and Nickel. Cobalt and nickel are associated with iron in what is called group 8 of the periodic table. The elements of this group occur in groups of three, which have comparable atomic weights, e.g. Fe (55·84), Co (58·94), Ni (58·69); they are called transition elements because they bridge the gap between the elements on the left hand of the table (Lesson 4, Volume 1, page 160), which belong to sub-groups A, and those on the right side, which belong to sub-groups B.

Cobalt and nickel occur together in Nature, usually in the form of sulphide or arsenide. Cobalt ores are first converted to oxide by roasting in air and then reduced to metal by the Goldschmidt process or by heating with carbon. Nickel ores, which usually contain iron and copper, are roasted in a blast or reverberatory furnace to remove arsenic, and then transferred to a converter similar to that used in the Bessemer steel process. Most of the iron, present as impurity, is converted into slag, and the resulting mixture of nickel and copper sulphides is roasted to oxide and refined either by fusion with coal and sodium sulphate or by the Mond carbonyl process (*see* Lesson 20, Volume 2, page 151).

Both metals are silver-white in appearance and resemble iron in density, melting-point and magnetic properties. They are,

however, much more resistant to corrosion, and for this reason have found important industrial uses in the preparation of non-corrodible alloys and in plating copper and iron vessels. The addition of nickel to steel gives alloys of great strength and varying degrees of elasticity. Steel containing 35 per cent of nickel, a little carbon and manganese is called invar, and does not show any appreciable expansion or change in elasticity when heated. Platinite, a steel alloy containing about 45 per cent of nickel, has almost the same thermal coefficient of expansion as glass, and is used for sealing leads into electric light bulbs and wireless valves. Nickel is also alloyed with chromium and with copper in the production of monel metal (Ni 60 per cent, Cu 35 per cent, Fe 5 per cent) and of German silver (Ni 25 per cent, Cu 55 per cent, Zn 20 per cent). The use of finely-divided nickel as a catalyst has been mentioned (Lesson 15, Volume 2, page 127); this was first discovered by Sabatier and Senderens, who found that when hydrogen and the oxides of carbon were passed over hot catalytic nickel, methane and water are formed.

Compounds of Cobalt and Nickel. These metals form several series of compounds, of which the divalent ones, corresponding to the oxides, CoO (cobaltous) and NiO (nickelous), are the most important. Both oxides are formed by the action of heat on the hydroxide or carbonate, and dissolve in mineral acids to form the appropriate salt. Cobalt salts are generally pink, an exception being cobalt hydroxide, $Co(OH)_2$, which is formed as a blue precipitate when a caustic alkali is added to a cobaltous solution. On boiling, the hydroxide becomes pink, presumably owing to a change in the degree of hydration. Nickel salts are generally green, and on treatment in solution with a caustic alkali give an apple-green precipitate of nickelous hydroxide.

When sulphuretted hydrogen is passed into a solution of a cobalt or a nickel salt which has been made alkaline with ammonia, finely divided black precipitates of the sulphides are formed. These sulphides are insoluble in dilute acids, though, curiously enough, they are not precipitated if the solutions are first made slightly acid. The most probable explanation is that there are two modifications of the sulphides, the less stable being soluble in acid.

Platinum Metals. Two other triads of elements (cf. Fe, Ni and Co) occur in group 8 of the periodic table, namely ruthenium, rhodium and palladium, which form the bridge between the A

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and B sub-groups of the second long period, and osmium, iridium and platinum, which are the transition elements of the third long period. All of these metals are comparatively rare, and because they are unreactive and occur in the free state in Nature, they belong to the class called the "noble" metals. Palladium, iridium and platinum are the most important.

Palladium differs from the other two in that it dissolves fairly readily in nitric and strong sulphuric acids All three metals dissolve in aqua regia (3 parts of HCl to 1 of HNO_3), and if this solution is gently heated with hydrochloric acid until all the nitric acid is expelled, the quadrivalent chloride of the metal is obtained. These chlorides are comparatively unstable, but if recrystallized from a solution containing ammonium chloride, they form a stable complex salt of the type $(NH_4)_2PtCl_6$, ammonium chloroplatinate, which is the salt of chloroplatinic acid (H_2PtCl_6). When heated, this salt decomposes, giving first platinum chloride and ammonium chloride and, finally, with stronger heating, finely-divided platinum. Platinum, especially when *in a fine state of subdivision, is a powerful catalyst*; the activity of colloidal platinum and the use of platinized asbestos in the catalytic preparation of sulphuric acid have been mentioned. In the latter case the catalyst is prepared by heating asbestos which has been soaked in a solution of chloroplatinic acid.

Because of its rarity and resistance to corrosion, platinum is selected as a setting for jewelry. Its thermal coefficient of expansion is almost exactly the same as that of glass, and it finds an important use as a means of sealing metal leads into electric light bulbs.

LESSON 30

Penetrating the Atom's Secrets

(See plate 41)

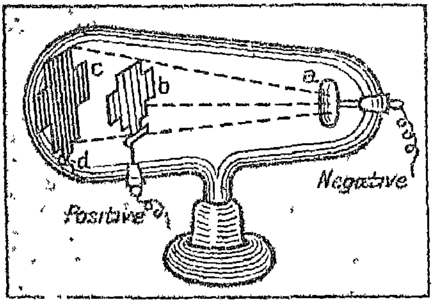
THE quantitative laws of chemical combination are based on the assumption, put forward by John Dalton, that all matter is composed of minute, indestructible particles called atoms. For a long time it was believed that these atoms could not be further subdivided—the word "atom" means indivisible—and that the eighty or so different atoms which constituted the then known elements were completely unique

and had nothing in common with one another. The first suggestion that this was not so came from the English chemist, Prout, who put forward the theory, shortly after Dalton's hypothesis, that hydrogen atoms were the fundamental ones, and that the atoms of the heavier elements were aggregates of numbers of hydrogen atoms. It was found, however, that the atomic weights of many elements were not integral multiples of the weight of the hydrogen atom, so the Prout hypothesis had to be given up. As will be seen later, however, it has recently come into its own, though the situation is rather more complicated than Prout anticipated. But although the indivisible atom proved sufficient for the purposes of the chemist, it did not satisfy the physicist; and as a result of a remarkable series of discoveries towards the close of the nineteenth century, it was definitely proved that the atoms themselves are composed of even more minute particles, called electrons and protons. These discoveries resulted from two particular lines of research—the search for the atom of electricity, which led to the isolation of the electron, and the investigations into the phenomenon of radioactive disintegration which led ultimately to the theory of the nuclear atom

Cathode Rays. The first suspicion that there might be an atom of electricity arose from Faraday's experiments on the electrolysis of salt solutions. It was found that if a given amount of electricity is passed through solutions of the salts of univalent metals, the amounts of metals deposited are proportional to the atomic weights—that is, the weight of the atoms—of these metals. Moreover, the amount of electricity required to deposit the atomic weight of a divalent metal is twice that required for the atomic weight of a univalent metal, that for a trivalent metal three times, and so on. This suggested that in electrolysis the atoms are accompanied by a unit of electricity or some integral multiple of this unit. In solutions, however, it was not possible to isolate this unit of charge from the atoms with which it was associated, so its properties could not be properly investigated. The actual proof of its independent existence did not, therefore, appear until the examination of the passage of electricity through gases

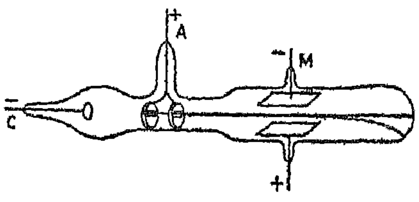
At ordinary pressures all gases are relatively poor conductors of electricity; for example, it requires about 30,000 volts to break the insulation of an inch of air. If, however, air contained

in a vacuum tube, as shown in Fig 1, is exhausted to a pressure of about 1/1000th of an atmosphere (about 1mm), it not only becomes a good conductor but also begins to glow with a brilliant pink luminosity As the pressure in the tube is further decreased, the appearance of the discharge goes through a variety of changes At first a dark space appears near the cathode (the negative electrode), and gradually spreads along the tube, until, when the pressure is only a few hundred thousandths of an atmosphere (about 0 01 mm), the glow within the tube has become very faint At this point the glass walls opposite the cathode begin to glow with a greenish fluorescence, and by putting into the tube some substance which casts a shadow, it can be readily shown that the fluorescence is caused by something which is being shot out from the cathode



CATHODE RAYS. Fig. 1. Vacuum tube for the detection of cathode rays a, cathode, b, anode and shadow-producing cross c, d, shadow

These "cathode rays," as they were called, were first observed by Sir William Crookes (1886), who suggested that they were merely streams of negatively-charged particles This was later proved to be the case by the experiments of Lenard and Sir J J. Thomson, who showed that a beam of cathode rays can be deflected from its course either by the aid of a magnet or by means of the electric field between the charged plates of a condenser (Fig 2).



DEFLECTION OF CATHODE PARTICLES. Fig. 2. The beam of particles shot out from the cathode C passes through slots in the anode A, and under the influence of the magnetic or electric field at M describes the curved path shown

Electron Velocity. From measurements of the deviations caused in this way by magnetic and electric fields, Sir J. J. Thomson

was able to estimate the velocity and also the ratio e/m between the charge e and the mass m of the particles. The velocity varies with the potential at the cathode, and may be as great as 50,000 kms. per second (about 30,000 miles per second, or 1/6th of the velocity of light); the ratio e/m always has the same value, irrespective of the nature of the metal at the cathode or of the gas in the tube, and, according to the best measurements, is 1,835 times greater than the ratio of charge to mass for the hydrogen ion during electrolysis. If it is assumed, therefore, that e is the elementary amount of electricity associated with the hydrogen ion in electrolysis—viz. $4{\cdot}77 \times 10^{-10}$ electrostatic units—then the mass of the cathode particles is 1/1835 of the mass of the hydrogen atom. These values of e and m have been confirmed by many independent measurements, those of the American physicist Millikan, to whom the best value of e is due, being especially noteworthy. Millikan's value was obtained from an investigation of the motion under the influence of an electric field of tiny oil droplets, which were allowed to pick up charges from electrified cathode particles.

It has now been shown that these negatively-charged particles can be obtained in a great variety of ways; for example, when a metal is heated to redness, as in a wireless valve, when X-rays or ultra-violet light are allowed to fall upon substances, or, as will be seen later, during the process of radioactive disintegration. But from whatever source they are obtained, they always have the same mass and charge; it is logical to assume, therefore, as Sir J. J. Thomson did, that they are free atoms of negative electricity, and, moreover, are a universal constituent common to all atoms. They are called "electrons."

X-Rays. One extremely important discovery which resulted from the phenomenon of cathode rays was the discovery of X-rays. These very penetrating rays—sometimes called Röntgen rays, in honour of their discoverer (1895)—are emitted when a stream of electrons meets the glass wall of the tube or a piece of metal placed diagonally in its path. Every X-ray tube used in hospitals, etc., consists essentially in a piece of metal, called the anti-cathode, bombarded in a highly evacuated tube by very swift electrons (Fig. 3, Plate 41). Like cathode rays, X-rays excite fluorescence of various substances, cause ionization and also affect a photographic plate. Unlike cathode rays, however, they are not deflected by a magnetic field, and so are not electrically-

charged particles; because of their tremendous penetrating power—they pass through thin layers of metal with great ease—and of the fact that they cannot be reflected, refracted or diffracted, it must be assumed that they are of much shorter wave-length than the most extreme ultra-violet rays Expressed in Ångstrom units—the units of wave-length—X-rays have an average length of 1Å.U. as compared with 2,000 Å.U for very short ultra-violet light and about 5,500 Å.U. for visible yellow light

The Proton and Ionization. The discovery of the atom of negative electricity led to the search for the atom of pure positive electricity Since atoms are, in general, electrically neutral, the removal of one or more negatively-charged electrons might be expected to leave a positively-charged residue. This was actually shown to be the case by the German scientist Goldstein (1886), who demonstrated the existence in a vacuum tube of streams of positively-charged particles which were shot along the tube in the opposite direction to the cathode rays. In order to separate the "positive rays," Goldstein allowed them to pass through canals cut in the cathode; for this reason they are sometimes called "canal rays" Measurements of the deflection caused by the influence of magnetic and electric fields carried out by Sir J. J. Thomson, Aston and others have shown that the velocity of positive particles is, in general, much less than that of electrons—it is of the order of a few hundred kms. per second; moreover the ratio of charge to mass is about the same as in electrolysis, that is about 1/2000th as much as in the case of the electron. It must be assumed therefore, that these positively-charged particles are some thousands of times heavier than the electron, and, in fact, are merely atoms of matter having a positive charge.

Particles produced in this way are called "ions"; the process of ionization, therefore, consists merely in knocking out one or more electrons from the atom and leaving behind the relatively heavy positive ion containing the rest of the atom. Ionization may be caused by high electrical potentials, by swift particles, such as the electrons themselves, or by energy-rich rays, such as X-rays or ultra-violet light.

Since the hydrogen atom is the lightest known, it is generally believed that the hydrogen ion is the smallest positively-charged particle. It is called the proton, and has been shown to be one

of the fundamental bricks in the structure of all atoms (the other being the electron). The discovery of the electron and the proton led at once to the modern theories of the structure of the atom, based largely on the phenomenon of *radioactivity.* In 1932 some experiments carried out at the Cavendish Laboratory at Cambridge confirmed the existence of a positively-charged particle having the same mass as the electron, and known as the positron. The positron is always accompanied by an electron and is only a product of bombardment, not a part of the atomic structure. That year Chadwick discovered the neutron, a particle with mass but no charge. The union of two protons with two neutrons yields an α-particle This will be dealt with in our next lesson.

LESSON 31

Radium and Radioactivity

THE study of the discharge of electricity through gases resulted in the discovery of three kinds of radiation; these are: cathode rays, which were proved to be due to electrons; positive rays, due to positively-charged ions; and X-rays, which are set up when cathode rays are reflected from some hard surface. All three of these rays possess the common properties of affecting a photographic plate, exciting fluorescence and ionizing gases through which they pass.

In 1896 Henri Becquerel noticed that crystals of uranium compounds, even without the excitation caused by an electric discharge, continually emitted rays which had similar effects to those obtained by means of a vacuum tube. He found, for example, that a photographic plate, even though well wrapped in black, light-proof paper, was extremely sensitive to the presence of a small amount of a uranium salt and also that when some of the salt was placed near a charged gold-leaf electroscope, the leaf slowly collapsed, showing that uranium had the property of making the air in its neighbourhood a good conductor of electricity. As will be seen later the intensity of these rays is completely unaltered by any of the factors (heat, light, concentration, electric fields, etc.) which have such a marked effect on chemical reactions. The phenomenon is, in fact, due to an intrinsic property of the atoms, and its epoch-making discovery led to the development of a new branch of science called "radioactivity."

Pioneer Work of the Curies. In 1898 Madame Curie, one of the pioneer workers in this new field, and Schmidt showed that compounds of the element thorium, the main constituent of Welsbach gas mantles, possessed radioactive properties of about the same intensity as those of uranium. In the same year (1898) Pierre Curie and his wife noticed that some natural ores from which uranium is extracted—called pitchblende—were as much as 8 times as radioactive as the uranium and thorium which they were known to contain. This suggested the presence of other, more strongly radioactive substances; and by careful fractional crystallization, in which both the filtrate and the precipitate were tested by means of an electroscope for radioactive materials, Madame Curie was able to separate the salts of two extremely active elements. The first of these, always associated with bismuth, to which it showed marked chemical similarity, was called polonium The other, of atomic weight 226·5, exactly analogous in chemical properties, spectrum, etc., to barium, was called radium; it is at least a million times more radioactive than uranium. With these more active substances, it was easier to investigate the complex radiations emitted.

Rays Emitted by Radium. The first analyses, carried out by Sir Ernest (later Lord) Rutherford, showed that the rays were of three types, which were analogous to those of the Crookes tube, and which, like them, could be readily distinguished by the differences in their power of penetrating matter, and also by the effect caused by subjecting them to an electric or a magnetic field. They were classified by Rutherford into alpha (α), beta (β), and gamma (γ) rays. Their properties may be summarized as follows: α-rays are composed of positively-charged particles (as shown by the deflection in a magnetic field) having a velocity about *one-sixteenth that of light* (12,000 miles per second) and a mass of the same order of magnitude as the masses of the atoms; their penetrating power is small, and they are stopped by a few centimetres of air. β-rays have been proved to be identical with cathode rays; they are composed of negatively-charged electrons having a velocity approximately nine-tenths of that of light. Because of their minute size and great velocity, they are at least 100 times more penetrating than α-rays, and lose scarcely half their intensity after passing through 1 metre of air. γ-rays are not deflected even by the most powerful magnetic field, and are extremely penetrating, passing through a sheet of lead up to 8

cms. in thickness. Like X-rays, to which they are analogous, they appear to be pulsations and not streams of particles (cf. α- and β-rays), and are due to the bombardment by the β-rays of the solid matter of the radioactive material (see fig. 1).

The properties of each of these rays vary considerably according to the radioactive source; for example, the penetrating power of α-rays from radium is generally at least twice as great as that of α rays emitted by uranium. Moreover, the proportions of α-, β- and γ-rays to the total radiation vary according to the radioactive substance, and in some cases — for example, polonium, which emits only α-rays—it is found that all three radiations are not emitted by one and the same element.

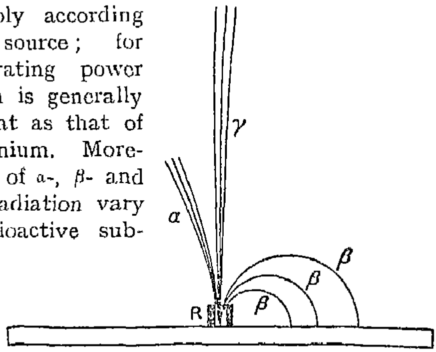


Fig. 1. Diagram showing action of a magnetic field on α-, β-, and γ-rays R represents source of radium.

Energies of Radium. It was noticed that the temperature of radium-bearing materials is always slightly higher than that of the surrounding air, and in 1903 Pierre Curie measured, by means of a special calorimeter, the amount of energy continually being radiated in the form of heat. This proved to be 130 calories per hour per gram of radium—or, expressed otherwise, the amount of energy radiated as heat by 1 lb. of radium in 1 year is equivalent to that obtained by burning 1½ cwts. of coal—and unlike coal, which, once burnt, ceases to be a source of heat, radium goes on continually evolving heat at that rate for hundreds and hundreds of years.

The discovery of this enormous and hitherto unsuspected source of heat offered an explanation as to why the age of the earth, as calculated from its rate of cooling, is considerably less than the estimate of the geologists. It is now assumed that, in addition to the heat radiated by cooling, a large quantity is being continually given off by radioactive substances in the earth's crust. In the same way, the age of the sun, calculated on the assumption that its heat is produced by continual gravitational shrinkage, falls very far short of geological and astronomical estimates, and

can be considerably extended by assuming that it contains radioactive materials. It is important to notice, however, in the latter case, that the heat radiated by the sun cannot be wholly attributed to that resulting from radioactivity. Even if the sun consisted entirely of uranium, the amount of heat resulting from its disintegration would only account for half the heat radiated.

Transmutation of Elements. It had been observed by the Curies that substances placed in a sealed tube together with a radium salt appeared after a short time to have acquired radioactive properties, which gradually disappeared when the substance was removed from the sphere of influence of the radium. These and other phenomena pointed to the formation of a gaseous emanation, which was emitted by the radium and able to diffuse into matter with which it came in contact. This was actually shown to be the case by Rutherford, who pumped out an evacuated tube containing radium, and obtained small quantities of a hitherto unknown gas The " radium emanation," as it was first called, was proved to be an element analogous to the rare gas, argon; it liquefies at $-65°$ C. and solidifies at $-71°$ C. to a self-luminous solid; like the inert gases, it is monatomic, and its atomic weight was estimated to be 222. It was given the name of niton (shining) by Sir William Ramsay.

Niton is being continuously liberated from radium at the rate of one-tenth of a cubic millimetre per day per gram. Moreover, the very curious fact was observed by Rutherford that after a certain length of time—thirty days, in fact—the amount of niton in contact with a given amount of radium reached a maximum value, which was never exceeded, however long the radium was left. The only explanation seemed to be that the niton itself was undergoing spontaneous radioactive decay, and by isolating some of the gas Rutherford was able to show that this was, indeed, the case. Niton emits at first only α, then later β- and γ-rays very strongly; mass for mass, in fact, it is far more intensely radioactive even than radium; after four days only one-half of the gas remains, after eight days only one-quarter, and after one month less than one-thousandth.

Since the rate of decay of niton, like that of radium itself, is entirely unaffected by changes of temperature, pressure and so on, the energy causing this radioactivity cannot come from any external source, and must, therefore, come from the atoms

themselves. The rather startling conclusion is then arrived at that, in emitting its rays, the element radium is gradually decaying, and at the same time is producing a new element, niton, which is itself spontaneously disappearing. As will be seen later, the change from radium to niton is, in fact, only one of a long series of successive changes of similar character, which actually begin with the element uranium. Radioactivity is thus the sign of the transmutation or transformation of one element into another—in principle, the philosopher's stone, which the old alchemists had vainly tried to discover.

LESSON 32

Disintegration of the Atom

(See plate 41)

It has been mentioned in the previous Lesson that radium, in emitting its rays, gives rise to a new element, niton, which, like its parent substance, also gives off radiations and slowly decays. As a result of phenomena of this kind, characteristic of all radioactive substances, we are led to the conclusion that the process of radioactivity is the outward and visible sign that one element is being slowly transformed into another. Since such a transformation must involve a change of one kind of atom into another, the process is an atomic one. Moreover, the transmutations do not take place smoothly and gradually, but in sudden jerks. There is, for example, no intermediate step between the disappearance of radium and the formation of niton. The transformation occurs suddenly and explosively, each atomic explosion being accompanied by the shooting out of the various rays. This view that radioactivity is due to atomic disintegration, was suggested, in the first place, by Rutherford and Soddy, and later verified by them in some brilliant experimental work, and also by Sir William Ramsay.

As the result of an observation made by Ramsay, that small amounts of the rare gas helium were always found associated with radioactive minerals, Rutherford and Soddy suggested in 1903 that helium was one of the products of radioactivity. This was proved to be the case soon afterwards by Ramsay and Soddy, who examined the spectrum of niton, which had been freed from

other gases by being first condensed in liquid air, and then sealed up in a small spectrum tube. At first there was no evidence of helium, but in three or four days, as the niton disintegrated, the helium spectrum became stronger and stronger, until ultimately the whole characteristic spectrum of helium was given by the tube The disintegration of niton thus results in the liberation of helium atoms, and in the same way it was shown that helium is formed as well as niton when radium itself disintegrates

As has been mentioned in the previous Lesson, it follows from the nature of the deflection which α-rays experience in a magnetic field, that they are positively-charged particles Moreover, the same method of calculation as that employed for cathode rays showed that the ratio of charge to mass ($^e/_m$) was always about half the value of that ratio for the hydrogen ion It had to be assumed, therefore, that either the particles had a mass of 2 and carried 1 elementary charge or else had a mass of 4 and 2 elementary charges As a result of two completely different pieces of experimental work, the second alternative was proved to be the correct one The first method, used by Rutherford, was to determine the charge carried by each α-particle, or, in other words, the total charge carried by a known number of α-particles The total charge was measured quite simply by means of an instrument called an electrometer, counting the number of particles which conveyed that amount of positive electricity in a given time from the same radioactive source was a much more difficult problem This was first accomplished by making use of the property of α-rays of exciting fluorescence in certain substances, such as zinc sulphide. When an α-particle strikes a screen coated with zinc sulphide its presence is signalled by the emission of a tiny flash of light (a phenomenon made use of by Sir William Crookes in his spinthariscope), and by counting the scintillations caused in this way it was possible to estimate the number of α-particles striking the screen during a given time (*See* Plate 41, Fig 1)

This way of counting the particles was soon replaced by two much more accurate methods. It has been mentioned that, because of their tremendous velocity, α-rays have the property of being able to "ionize" gases through which they pass Ionized gases are good conductors of electricity, so that if the α-particles are allowed to pass into a gas chamber containing two plates

charged at different potentials and connected to a sensitive electrometer, each time a particle passes between the plates a small amount of electricity leaks across the plates, and is recorded by a distinct jerk of the electrometer needle. This method was developed at the Cavendish Laboratory, Cambridge, by Rutherford and Geiger, who found that the number of jerks corresponded to the scintillations obtained by the Crookes method.

An even more direct method of counting the particles was invented by Professor C. T. R. Wilson, also of the Cavendish Laboratory, in which the whole of the path of an α-particle is rendered visible to the eye. When ions are produced in a gas containing a certain amount of moisture in the form of invisible vapour, they form nuclei, much in the same way as specks of dust, for the condensation of the vapour. If, therefore, an α-particle is allowed to pass into a chamber containing moist air, and the air is suddenly cooled by allowing the chamber to expand, with suitable illumination the path of the particle appears as a clearly-defined white line of fog. These streaks of fog can be readily photographed (Fig. 2, Plate 41), and so provided an ingenious method of counting α-particles. They were also of great importance in solving the problem of the nature of the nucleus, a subject that is dealt with in a later Lesson.

Range of Atomic Projectiles. One other series of experiments served to remove all doubt as to the identity of α-particles and helium atoms. It has been mentioned that α-particles are shot out from radioactive material with an enormous velocity, the average value being $1{\cdot}7 \times 10^9$ cms. (about 12,000 miles) per second. Because of this extremely high velocity, these particles have fairly strong powers of penetration; they are able to pass through 3 to 5 cms. of air at normal atmospheric pressure. Owing to the greater densities of liquids and solids the range is smaller in them than in gases, but, even so, the particles can pass through homogeneous thin sheets of aluminium or mica from 0·02 to 0·06 mms. (about one five-hundredth of an inch) in thickness. Making use of this property, Rutherford was able to collect α-particles in the following way: radium emanation was introduced into a glass tube with walls thin enough to allow the passage of α-rays, but strong enough to be airtight. This thin-walled tube was then enclosed in an evacuated tube with walls of ordinary thickness, impermeable to α-rays. After a short time it was possible to detect helium in the space between

the two tubes; the amount of helium produced by 1 gram of radium in 1 year was estimated to be 167 cubic mms. There is no doubt, therefore, that α-particles are helium atoms which carry two positive charges.

Disintegration of Radium. The atomic weight of radium is 226 and that of niton is 222; each atom of radium in disintegrating splits up into a niton atom and a helium atom, which is expelled at great velocity. Moreover, only a certain fraction of the total number of atoms present splits up in every second, and it is this proportion of the disintegrating atoms which determines the life period of the radioactive element. In accordance with the usual dynamical law, it is to be expected that when an α-particle is shot out from an atom at tremendous speed, the residue would acquire a momentum in the opposite direction. This radioactive recoil was actually found to take place, and was the means of the isolation and investigation of many subsequent disintegration products which were too short-lived to be treated in the ordinary way. The method used was to allow the recoil product to deposit on a convenient surface, and since the product shortly after formation acquires a positive charge, the deposition was greatly increased if the surface was charged with a negative potential. The nature of each of these short-lived active deposits was investigated by examining the types of rays they emitted, their power of penetrating matter, of exciting fluorescence, of discharging an electroscope, and so on.

Radium and Lead. It had been observed by the Curies and others that uranium ores always contained a certain amount of lead. Moreover, in his investigation of niton, Rutherford noticed that in addition to the liberation of helium, a solid deposit which strongly resembled lead began to appear on the walls of the vessel in which the emanation was contained. These two facts supplied pieces of evidence for what was later worked out by inference; we now know that lead in some form or other is the ultimate product of radioactive decay.

By the methods which have been described, more than 30 new simple substances, which are derivatives of uranium and thorium and have life-periods varying in length from one twenty-fifth of a second to 1,000,000,000 years, have been discovered. It is found, in all cases, that the rate of decay is rapid at first and gradually becomes slower, which is rather to be expected on the theory that a definite proportion of the atoms present

MAIN URANIUM SERIES OF RADIOACTIVE ELEMENTS

Half-life	Element	Rays	Atomic Weight	Atomic Number
$4 \cdot 67 \times 10^9$ years	Uranium I	α	238	92
24 days ..	Uranium X_1	β, γ	234	90
1·17 minutes	Uranium X_2	β, γ	234	91
About 10^6 years	Uranium II	α	234	92
$6 \cdot 9 \times 10^4$ years	Ionium	α	230	90
1,690 years ..	Radium	α, γ	226	88
3·85 days ..	Niton	α	222	86
3 minutes ..	Radium A	α	218	84
26·7 minutes	Radium B (lead)	β, γ	214	82
19·5 minutes	Radium C	$(\alpha), \beta, \gamma$	214	83
10^{-6} second ..	Radium C^1	α	214	84
17 years ..	Radium D (lead)	β, γ	210	82
5 days ..	Radium E	β	210	83
140 days ..	Polonium	α, γ	210	84
Stable ..	Lead	—	206	82

in each case are disintegrating in each second. In the case of radium this proportion is only 13 in every billion (10^{12}) atoms. Expressed mathematically, the rate of decay is an

function; it becomes infinitely slow when almost all the substance has decomposed. It is usual, therefore, to express the rate in terms of the time taken for half the atoms present to decay—the "period of half-life," as it is usually called. The total life-period is roughly obtained by multiplying this value by 10.

The main radioactive series of elements, that derived from uranium, is shown in the table in page 219. Side chains sometimes occur, as, for example, at radium C. As will be seen from the table, when an α-particle is emitted the atomic weight decreases by 4 and the atomic number by 2, but when a β-particle is emitted the atomic weight is unaltered although the atomic number increases by one.

LESSON 33

The Wonderful Universe of the Atom

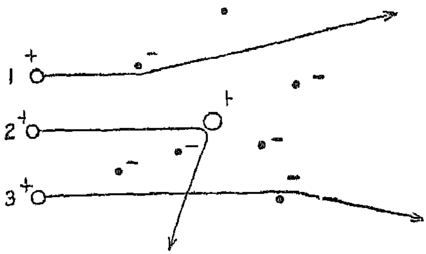
(See plate 41)

As a result of the discoveries of the electron and the phenomena of radioactivity, the old view of the atom as a solid, indivisible unit was ultimately discarded. It was proved that all atoms are composed of positive and negative particles, and the following questions naturally arose: what positions do these particles take up with respect to one another? how many of each kind are present? and how are these internal arrangements of the atom connected with its physical and chemical properties?

Much light was thrown on these questions by Rutherford's experiments on the penetration of matter by swift α-particles. It has been mentioned that these particles are shot out from radium with a speed of about 10,000 miles per second, and so, in spite of their lightness, they have a comparatively large energy; they are, in fact, able to pass through plates of mica and aluminium up to five-hundredths of a millimetre in thickness, and, since it is extremely unlikely that they pass in between the densely packed atoms of the plate, it must be concluded that they travel clean through the atoms themselves. Rutherford allowed a dense stream of α-particles from a strongly radioactive source to pass through thin metal plates in this way, and observed the paths which they took by watching the tiny flashes of light produced on a zinc sulphide screen. He found that, while the

majority of the particles were deflected only slightly from their straight-line paths, a few—about 1 in every 10,000—were turned aside through very large angles some actually appearing to return almost in the direction in which they had come

Now α particles are doubly charged helium atoms having a mass about four times that of the hydrogen atom while electrons are approximately only one eighteen hundredth as heavy as the hydrogen atom A swift-moving α-particle therefore, on colliding with an electron would merely brush it aside, it thus had to be concluded that the large deflections were caused by something considerably more massive Rutherford was then led to the hypothesis that practically all of the mass of the atom is concentrated into a positively charged and very small nucleus, and that the large deflections were due to the tremendous forces of repulsion suddenly created when an occasional positively charged particle passed very near to the nucleus This is shown diagrammatically in Fig 1



TRACKS OF ALPHA-PARTICLES. Fig 1 Diagram showing tracks in the interior of matter While 1 and 3 undergo small deflections by collisions with electrons, 2 is sharply deflected by a positive nucleus
From Kramers & Holst, "The Atom and the Bohr Theory of its Structure" Gyldendal

These phenomena were demonstrated rather more conclusively by the experiments of C T R Wilson (*see* Plate 41) who obtained photographs of the cloud tracks left by particles on passing through moist gases An enlarged picture of two such tracks is also shown in Plate 41 The path traced out by an unobstructed particle is shown as a straight line, the pronounced kink in the other line being due to a "collision" between an α-particle and the nucleus of the atom

Dimensions of the Atoms. Continued researches of this kind have definitely proved the correctness of Rutherford's nuclear theory of the atom It is now known that an atom consists of a dense, positively-charged kernel or nucleus, in which practically the whole of its mass is concentrated, and a number of negatively-charged electrons, which circulate about the nucleus in orbits of

different diameters, in much the same way as the planets circulate about the sun. The outer boundaries of the atom are marked by the orbits of the outermost electrons, contact between two atoms being the result of the forces of repulsion between the outer electrons Rutherford was able to show that the diameter of the nucleus is in the order of 10^{-13} of a centimetre, the diameter of the atom itself being of the order of 10^{-8} of a centimetre, i.e. about 100,000 times as large as the nucleus.

A better idea of the dimensions of an average atom may be obtained by magnifying it up to some familiar size If the nucleus were enlarged to the size of a cricket ball, the electrons would look like acorns, and would be rotating around the nucleus at distances varying from a few feet, for the nearest pair, to almost a mile, for the outermost orbits But perhaps the most startling conclusion from these discoveries is the fact that practically the whole of the volume of the atom consists of empty space. It has been estimated, for example, that if all the positive and negative particles in an average man could be condensed together with no space in between, they would occupy less than a millionth of a cubic millimetre. The fact that the atom is very largely space was, of course, first suggested by the ease with which α- and β-particles pass through the layers of atoms in mica and metal plates.

Nuclear Charge and Atomic Number. Since atoms are, in general, electrically neutral, the numbers of positive charges on the nucleus must be equal to the number of negatively-charged electrons circulating around it. Considerable importance, therefore, attaches to the determination of the magnitude of the positive charge of the nucleus, as this is equivalent to determining how many electrons the atomic shell contains. As a result of the work of Rutherford and a Dutch physicist, Van der Broek, it was proved that the charge on the nucleus and, therefore, the number of planetary electrons is equal to the order number of the element in the periodic table, the " atomic number " as it is now called. This was later verified by the brilliant investigations carried out by the young English chemist, Moseley, of the X-ray spectra characteristic of the different elements. It has been mentioned that X-rays are vibrations similar in nature to light waves, but of much shorter wave-length, and are obtained whenever cathode or β-rays impinge on some solid substance. Moseley found that the frequency of vibration of X-rays was

directly connected with the atomic number of the element from which they were reflected, and by measuring the frequency it was possible to determine the atomic number without any knowledge of the atomic weight of the element concerned As will be seen later, most of the characteristic properties of the atoms, especially the chemical properties depend on the number of its planetary electrons and so on the nuclear charge the atomic number, therefore, has a much greater significance than the atomic weight, and in fact clears up many anomalies which arose from the first periodic classification of the elements based on atomic weights The atomic numbers are given in the Table of Elements in Volume I, page 160

Isotopes. One convincing proof of the importance of the atomic number was furnished by the discoveries of Soddy, Fajans, Russell and others, of the existence of isotopes These elements have slightly different atomic weights (nuclear masses), but are practically identical in physical and chemical properties, and so were placed in the same group of the periodic table (Gr *isos* = equal, *topos* = place) The first examples were found among the radioactive substances Lead is often found in Nature associated with the elements uranium and thorium Moreover, careful determinations of the atomic weight of lead from these two sources have given values of 206 in one case and 208 in the other These values agree very well with the disintegration theory that the loss of 8 α-particles by a uranium atom gives an element of atomic weight $238 - 8 \times 4 = 206$ and of 6 α-particles by a thorium atom, $232 - 6 \times 4 = 208$ Ordinary lead obtained from other sources has an atomic weight of 207·2, and may therefore be considered to be a mixture of the two isotopes More recently it has been shown by the English physicist, Aston, that many non-radioactive elements are actually composed of mixtures of isotopes Aston's experiments were carried out in an instrument called the mass spectrograph, in which a stream of positive or anode rays is made to pass through a magnetic field The deflections of the particles are slightly different according to their masses, and the isotopes can thus be more or less separated Many elements which have fractional atomic weights have been shown to be mixtures of isotopes in this way, for example, chlorine normally has an atomic weight of 35 46, and is a mixture of isotopes of atomic weights 35 and 37 in the ratio of about 4 to 1. This suggests to some extent that the hydrogen atom

may be a fundamental unit in the structure of all atoms.

We have seen that the chemical individuality of the atom is defined by the number of the planetary electrons and, consequently, by the charge of the nucleus. If, therefore, the nuclear charge were kept constant, although the mass of the nucleus were altered we should have the phenomena of isotopes. This has been proved to be the case, and will be dealt with in our next Lesson.

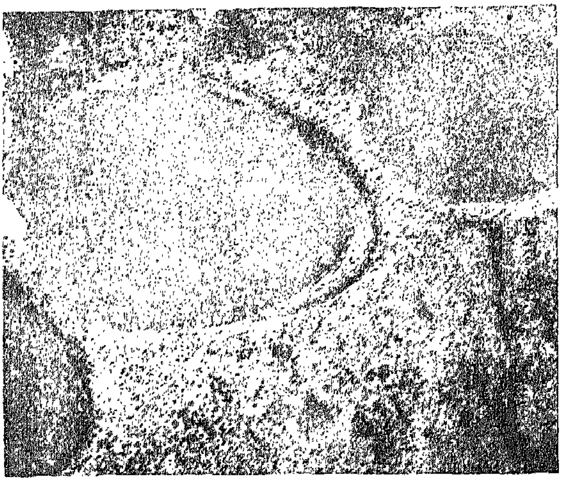
LESSON 34

Structure of the Atom

The emission of α-particles from radioactive elements indicated that the nuclei of these atoms are not elementary, indivisible particles, but contain a certain number, at any rate, of helium nuclei—that is, helium atoms stripped of their two electrons. It was later suggested by the Danish chemist Bohr that the β-particles (electrons) shot out by radium also came from the nucleus of the atom, and that, in addition to the planetary electrons, there are—in radioactive atoms, at any rate—some special nuclear electrons. The question then arose: is the helium nucleus the fundamental brick in the structure of the nuclei of all atoms?

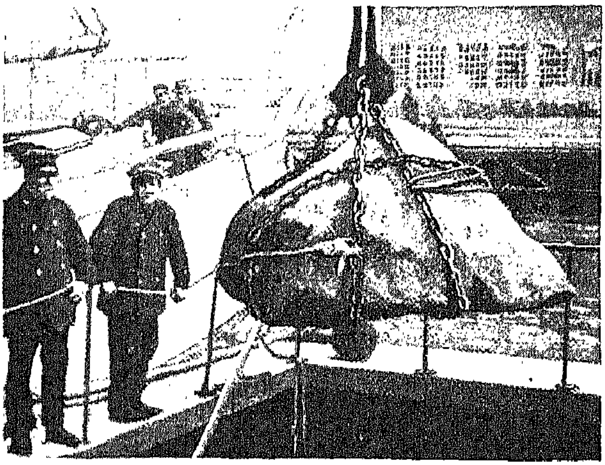
Some evidence that this might be so was provided by the phenomena of radioactive disintegration, which showed that the helium nucleus, if not an elementary unit, was a singularly stable aggregate. The fact that the weights of the lighter atoms are not simple multiples of 4, however, indicated that the helium atom is not an elementary particle; and since the hydrogen nucleus, or proton, is the smallest positively-charged unit known, the simplest assumption is that the nuclei of the atoms are aggregates of protons "cemented" together, as it were, by a certain number of electrons. This was later proved to be true by Rutherford, who, by bombarding light atoms, such as nitrogen and aluminium, with streams of α-particles succeeded in dislodging some protons from the atomic nuclei.

The phenomena of isotopes can be readily explained as being due to the simultaneous loss by an atomic nucleus of one, two or more neutrons, or else the same number of both protons and electrons. Thus the nuclear charge remains constant, and so the chemical properties of the atom; but the mass is decreased by



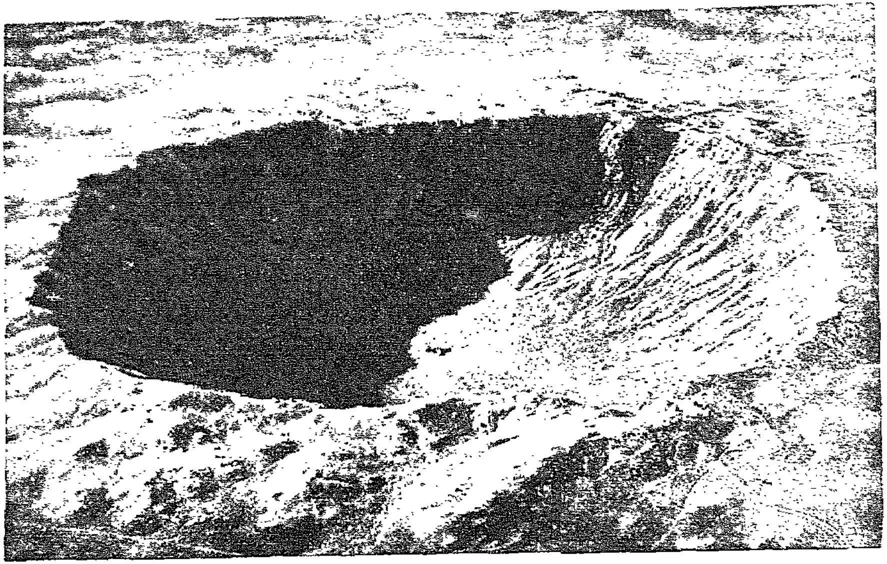
METEORIC SCARS. In South Carolina, U.S.A., there is an area of more than ten thousand square miles containing a large number of scars or "bays"—elliptical depressions in the earth with features which suggest that they were caused by a vast shower of meteorites a million or so years ago. ASTRONOMY 24

Photo, Fairchild Aerial Surveys



GIGANTIC AEROLITE THAT FELL IN GREENLAND. Here we see one of the largest known aerolites, discovered by the American explorer, R. E. Peary, in Greenland in 1894. It measures 11½ feet by 7½ feet by 1½ feet thick, and weighs 37½ tons. ASTRONOMY 24

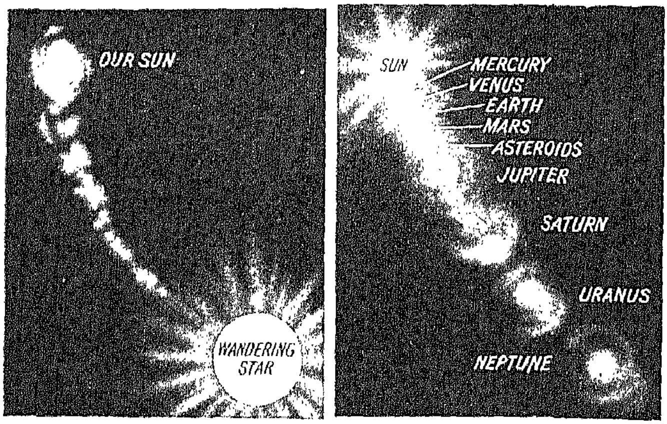
American Museum of Natural History



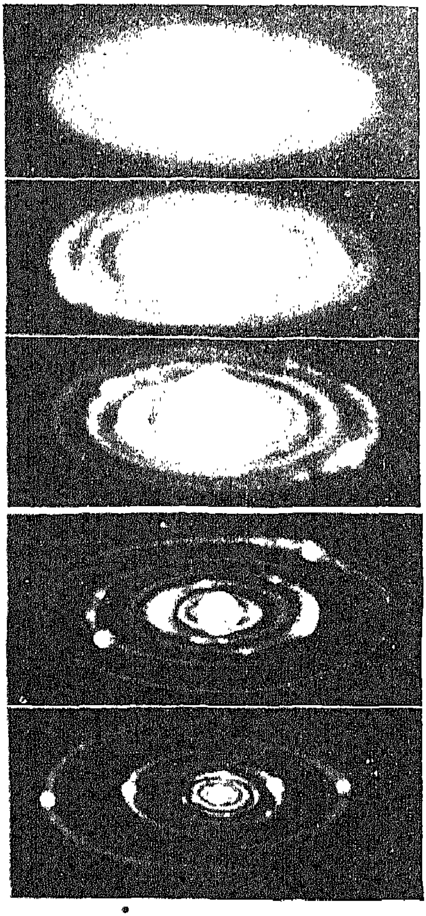
A METEOR CRATER IN ARIZONA. Countless ages ago a celestial projectile of vast dimensions fell in the desert of north-east Arizona, and Meteor Crater, near Winslow—here seen from the air—is the abiding memorial of the terrific collision. The cavity measures 1,500 yards in diameter, is 600 feet deep, and is surrounded by a ridge, 150 to 200 feet high, of matter thrown up by the impact. Scattered about the slopes and adjacent plain are fragments of meteoric iron, crushed rocks and boulders. ASTRONOMY 24

Photo. H. J. Shepstone

ZODIACAL LIGHT. Drawing showing at its perfection the luminosity that appears in the west sky after twilight or in the east before dawn. Though best seen in the clear skies of the East, it may be observed from London and many other places. It is suggested that the light is caused by the reflection of sunlight from meteoric masses still in the original plane of the solar system. ASTRONOMY 25



TIDAL THEORY OF THE SOLAR SYSTEM'S ORIGIN. The most generally accepted theory concerning the origin of the solar system of sun and circling planets is that at some inconceivably remote date a "wandering star" came so near to the as yet planetless sun as to cause tremendous waves on its surface and ultimately the drawing away into space of vast "blobs" of matter which settled down into planets. ASTRONOMY 25



LAPLACE'S NEBULAR HYPOTHESIS. To explain the evolution of the solar system, the French astronomer Pierre Simon, Marquis de Laplace (1749–1827), postulated an immense cloud of glowing gas shrinking as it lost heat and revolving faster as it shrank. At critical moments centrifugal force threw off rings of matter which condensed into the planets; the residue is now our sun. These drawings illustrate the various stages of the suggested process. ASTRONOMY 25

one, two or more units of weight. According to the theory, then, the atom of hydrogen consists of a positively-charged nucleus of mass 1·0078 with one negatively-charged electron revolving around it; the next largest atom, helium, has an atomic number 2 and a mass of 4. The helium nucleus, therefore, contains 2 protons and 2 neutrons, and has 2 electrons revolving around it. The nitrogen atom has atomic number 7 and atomic weight 14; there are thus 7 protons and 7 neutrons in the nucleus, and 7 extra-nuclear, planetary electrons. Formerly the nucleus was supposed to contain a number of cementing electrons, the excess of protons over electrons equalling the atomic number; but the discovery of the neutron has eliminated the necessity of these, thus simplifying our picture of the nucleus. When the number of protons exceed 104, however, the electrons in the nucleus are unable to prevent the charges from flying apart and the spontaneous disintegration, characteristic of the radioactive elements, results.

Energy in the Atomic Nucleus. We have seen that the nucleus of the helium atom is composed of 2 protons and had a mass of 4·00. Two protons and two neutrons of mass 1·0081 and 1·0067 give a mass of 4·0296; so that, even neglecting the very small mass of the electrons present, the formation of a helium atom results in the complete disappearance of 0·03 units of mass, or rather less than 1 per cent of the mass of the 4 hydrogen nuclei. This rather startling fact is in entire opposition to the old classical theory of the conservation of mass—that matter can never be destroyed. The modern view, however, put forward by Einstein in his Relativity Theory, is that mass, being the result of positive and negative electric charges, is merely another form of energy, and that a decrease in mass corresponds to the emission of a definite amount of energy in some form. This theory of the liberation of energy as the result of the annihilation of matter has recently received considerable support from the discovery of cosmic radiation. This radiant energy, which is constantly falling on to the earth from the outer regions of space, is presumably liberated by the mutual destruction of positive and negative particles.

Using Einstein's formula (energy = mass × c^2, c being the velocity of light), it can be calculated that the amount of energy liberated by the " destruction " of one gram of matter would be equivalent to that obtained by burning 3,000 tons of coal. Or,

to return to the helium atom, the amount of energy liberated in the formation of one ounce of helium from hydrogen would be sufficient to supply one million horse power for seven years. These almost fantastic stores of what is called sub-atomic energy have, so far, remained well beyond the reach of Man. There is no doubt, however, that in some of the hotter stars energy is being constantly liberated in this way by disruptions of the nucleus of the atoms. In 1939 Joliot split uranium atoms in half by bombardment with neutrons, releasing 4 more neutrons which might be available to split four more uranium atoms, thus releasing 16 neutrons and so on. In this way enormous energy would be released in a short time. No practical amounts have been obtained yet owing to dispersal of the chain effect by the initial disruption.

Electronic Structure of the Atom. So far we have been considering the constitution of the atomic nucleus, the next point to be settled is the arrangement of the extra-nuclear planetary electrons. It has been mentioned that the outer boundaries of the atom are defined by the orbits of the outermost electrons, and the formation of a chemical compound may be crudely regarded as the result of an interaction between the outer boundaries of two or more atoms and an interlocking of the orbital electrons. The chemical properties of the elements are thus defined, more or less, by the arrangements of the outer planetary or orbital electrons, and also by their number, which, we have seen, is the same as the nuclear charge, or atomic number, of the element considered. The modern view of the electronic structure of the atom is based on the theory put forward in 1913 by Bohr to account for the facts which had been observed in connexion with the spectra emitted by hydrogen atoms

We know that atoms, according to the manner in which they are excited—that is, by being heated or subjected to an electric discharge or a stream of swift β-particles—can emit energy in the form of infra-red radiation (heat), visible light, ultra-violet light or X-rays, all of which are electro-magnetic waves of different wave-lengths. It was supposed, also, that these emissions of energy are the result of an electron changing from an orbit of higher energy to one of lower, though no explanation of such a change could be made on the classical, electro-dynamical theory. Bohr, however, started with the assumption that the electrons cannot take up a position at random with respect to the nucleus,

but that each electron, for some inexplicable reason has a certain number of stable orbits in which it can rotate. While it is in one or other of these orbits it neither emits nor absorbs radiation—it is in what is called a " stationary state " ; but if it passes from one orbit to another it emits a quantum of vibration, the frequency of which depends on the relative positions of the two orbits concerned. The frequency ν of this " quantum jump " as it is called, is, in fact, given by the formula $h\nu = E_1 - E_2$, where h is Planck's constant and E_1 and E_2 are the energies of the two orbits With these assumptions, Bohr was able to account for all the observed lines in the spectra of hydrogen.

Moreover, as seen from the above formula, as the energy difference $E_1 - E_2$ increases, the frequency ν of the radiation also increases and the wave-length, therefore, decreases. In other words, with an increase in the energy of the orbit, from which the electron moves, the type of radiation emitted changes from infra-red rays to visible light, to ultra-violet and, ultimately, to X-rays. Since the energy of the orbits is mainly determined by the nearness of the electron to the nucleus, transitions from inner orbits result in the emission of X-rays. From an analysis of the frequencies of X-rays emitted by atoms when subjected to streams of β-particles (cf. Moseley's experiments on atomic numbers) it was possible to obtain information about the inner grouping of electrons in the atoms It must be remembered that when an electron is shaken out of its orbit, it cannot pass into the next adjacent orbit if that one is filled ; on the average, it prefers to pass out of the atom entirely, leaving it " ionized," or else to take up a position in the outermost incomplete group of electrons

By means of the optical and X-ray spectra of elements, it has been possible to determine the electronic structures of atoms. It is then found that the inert gases mark definite stages in the progress of atom building, each one having an outer group of *8 and inner groups of 8, 12 or 32 electrons.* The chemical inertness of the rare gases indicates that their electronic configurations —in particular, the outer groups of 8 electrons—are remarkably stable. Moreover, the repetition of chemical and physical properties of the elements in between the rare gases, as arranged in the periodic table, can easily be accounted for as being due to the successive building up of the outer group of 8 electrons around a stable inert gas structure.

The table below gives the structure of the inert gases and also the elements of the first short period (*see* Periodic Classification Lesson 4 Volume 1, page 160) which are typical of later elements The electrons are placed in different categories called " quantum

Quantum Group	1	2	3	4	5	6
He (2)	2					
Li (3)	2	1				
Be (4)	2	2				
B (5)	2	3				
C (6)	2	4				
N (7)	2	5				
O (8)	2	6				
F (9)	2	7				
Ne (10)	2	8				
A (18)	2	8	8			
Kr (36)	2	8	18	8		
Xe (54)	2	8	18	18	8	
Em (86)	2	8	18	32	18	8

groups," depending on the number of quanta of energy corres ponding to the orbits of that group Each of these groups should really be split up into a number of smaller groups, called sub groups.

Our Course in Chemistry is continued in Volume 5

LESSON 22

Terminology of Geometrical Drawing

THE term Geometry (Greek: *ge*, earth; *metron*, a measure) originally signified land measuring; but it now denotes the science of magnitudes in general, with their various properties and relations We here follow the practical side of the subject, as the theoretical is dealt with in our Course in Mathematics.

The student should always work with the greatest possible accuracy and neatness. Whatever instruments are used should be of the very best quality, in order to avoid errors and vexation The following are absolutely essential: a half-imperial drawing-board and pins, with its adjacent long and short edges perfectly perpendicular to one another; a T-square, which is used for drawing lines parallel to the edges of the board; two set-squares, having respectively angles of 45° and 60° (these are used to obtain perpendiculars and parallels); a pair of compasses with movable pen and pencil legs (those with needle points are best, as they do not make large holes in the paper); a pair of dividers for measuring; a mathematical pen for ruling lines in ink; two pencils, one HH for the construction lines and the other HB or F for the darker lines of the figure, sharpened wedge-shaped; cartridge paper for ordinary pencil work, and "hot-pressed" surface paper for ink drawings; protractor, either semicircular or as a flat ruler for measuring angles; foot-ruler, with tenths of an inch marked on it, as well as the usual divisions, and also centimetres and millimetres; and some Indian ink.

DICTIONARY OF ELEMENTARY TERMS IN PLANE GEOMETRY.

ACUTE ANGLE. An angle that is less than a right angle.

Acute-angled Triangle. See Triangle.

Adjacent Angles. Angles with a common vertex and one common arm.

Altitude of Triangle. See Triangle.

Angle. The inclination of two straight lines which meet in a point, or *vertex*. The size of an angle does not depend upon the length of the lines forming it, but upon their inclination to

each other The sum of all the angles in any one triangle is equal to two right angles, or 180°

Apex *See* Triangle

Arc Any part of the circumference of a circle between any two points in it

Area *See* Figure

BASE *See* Triangle

Bisect To cut into two equal parts.

CHORD A straight line joining any two points in the circumference of a circle

Circle A plane figure contained by one curved line, which is called the *circumference* or *periphery*, and is such that all straight lines drawn from a certain point within the figure to the circumference are equal to one another This point is called the *centre* of the circle, and each of the straight lines is called a *radius* of the circle The straight line drawn through the centre and terminated at both ends by the circumference is called the *diameter* which divides the circle into two *semicircles*, and if two diameters are drawn perpendicular to each other each of the four parts of the circle is called a *quadrant*

Complement of an Angle The difference between it and a right angle

Concentric Circles Those which have the same centre but different radii

Curved Line One that is nowhere straight.

DECAGON *See* Multilateral Figures.

Diagonal Line joining two opposite angles of a quadrilateral figure.

Duodecagon *See* Multilateral Figures.

EQUILATERAL TRIANGLE *See* Triangle.

FIGURE A space enclosed by one or more lines or boundaries. The sum of all the boundaries is called the *perimeter*, and the space within the perimeter is called the *area*.

HEPTAGON. *See* Multilateral Figures.

Hexagon *See* Multilateral Figures

Horizontal Line One that is perfectly level.

Hypotenuse *See* Right-angled triangle

IRREGULAR POLYGONS *See* Multilateral Figures

Isosceles Triangle *See* Triangle

LINE This has length without breadth, and may be represented by various methods, as thick, thin, dotted, or chain lines

MEDIAN. A line drawn from the vertex of a triangle to the middle point of the opposite side.

Multilateral Figures or *Polygons*. Figures contained by more than four straight lines. *Regular polygons* have all their sides equal, and *irregular polygons* have their sides unequal. Polygons are divided into classes according to the number of their sides: *pentagon*, having five sides; *hexagon*, having six sides; *heptagon*, having seven sides; *octagon* having eight sides; *nonagon*, having nine sides; *decagon*, having ten sides; *undecagon*, having eleven sides; *duodecagon*, having twelve sides.

OBLIQUE LINE. A line that slants.

Oblong. *See* Rectangle.

Obtuse Angle. An angle larger than a right angle.

Obtuse-angled Triangle. *See* Triangle.

Orthocentre. The intersection of the perpendiculars from the corners of a triangle to the opposite sides.

PARALLEL LINES. Lines such as are in the same plane and never meet though produced indefinitely.

Parallelogram. *See* Quadrilateral Figure.

Perimeter. *See* Figure.

Periphery. *See* Circle

Perpendicular. *See* Right Angle.

Plane. A level surface, and such that, if any two points be taken in it, the straight line joining these two points lies wholly in that surface.

Point. This has position only, without magnitude, and in practice is usually represented by a dot.

Polygons. *See* Multilateral Figures.

QUADRANGLE. *See* Quadrilateral Figure.

Quadrant. *See* Circle.

Quadrilateral Figure, or *Quadrangle*. A figure contained by four straight lines, as the square, oblong, rhombus and rhomboid. If the opposite sides are parallel it is called a *parallelogram*.

RADIUS. *See* Circle.

Rectangle, or *Oblong*. A four-sided figure with its opposite sides equal and all its angles right angles.

Rhomboid. Quadrilateral with its opposite sides equal, but its angles not right angles

Rhombus. Quadrilateral with all its sides equal, but its angles not right angles.

Right Angle. When a straight line meets another, so as to make the adjacent angles equal, each of the angles is called a right angle, and the lines are said to be *perpendicular* to each other. It should be observed that *perpendicular* does *not* mean upright or vertical, but *at right angles to another*

Right-angled Triangle A triangle with one of its angles a right angle The side opposite this right angle is the *hypotenuse*

SCALENE TRIANGLE *See* Triangle

Sector The space enclosed by two radii of a circle

Segment of a Circle The space enclosed by an arc and its chord.

Semicircle. *See* Circle.

Square. Quadrilateral with all its sides equal and all its angles right angles

Straight Line The shortest distance between two points.

Superficies, or *Surface* Extension in two directions; it has length and breadth, but no depth

Supplement of an Angle. The difference between it and two right angles

TANGENT. A straight line which touches a circle or curve at one point, but does not cut the circle or curve when produced. A tangent to a circle is at right angles to the radius

Theorem. A proposition to be proved by reasoning.

Trapezium. Quadrilateral with only two sides parallel, or, according to another definition, with no sides parallel.

Triangle. A figure contained by three straight lines. The side upon which it stands is termed its *base*, the point where the other two sides meet is its *vertex*, or *apex*; the angle at this vertex is the *vertical angle*, and the straight line which is drawn from the apex perpendicular to the base or the base produced is called the *altitude* Triangles are named, with reference to their *sides*

Equilateral, having three equal sides;
Isosceles, having two equal sides,
Scalene, having three unequal sides.

With reference to their *angles*

Right-angled, having one angle a right angle;
Obtuse-angled, having one angle obtuse,
Acute-angled, having all its angles acute.

UNDECAGON *See* Multilateral Figures.

VERTEX. *See* Triangle

Vertical Angle *See* Triangle.

LESSON 23

Exercises in Practical Geometry

THE exercises in practical geometry given below are of a preliminary nature and such as must be thoroughly grasped by the student before proceeding to more advanced work. As will be seen, they are concerned with lines, angles and proportionals.

1. To bisect a given line AB. The best way is to do it by trial with the compasses. Another method (1a and b): With centre A and any radius longer than half the line, describe an arc. With centre B and same radius, intersect it in C and D. Draw CD, which bisects the given line at right angles.

2. To draw a perpendicular to a given line AC, from a given point A within or B without the line. This may be done in several ways by intersecting arcs, but the most practical, most accurate and quickest is by placing a ruler level with the line AC, and a set square with one of the edges exactly touching the ruler. and the other passing through the given point.

3. To bisect a given angle ABC. With centre B and any radius describe an arc to cut the lines in A and C. With centres A and C and any radius describe arcs to intersect in D. Draw BD, which bisects the angle. By this means an angle may be divided into 4, 8, 16, etc., equal parts.

4. To trisect a right angle ABC. With centre B and any radius describe the arc AC. With centres A and C and same radius cut the arc in D and E. Draw BD and BE, which trisect the right angle.

5. To draw a line parallel to another AB, at a given distance C from it, or through a given point D At any point in AB draw a perpendicular GF equal to the distance C. Place one edge of a set square level with AB, then a ruler against another edge of the set square. Hold the ruler firmly fixed, but slide the set square along it until the edge (which was level with AB) passes through F, and draw FE the required line. When the point as D is given, the method is the same except that no perpendicular is required.

6. To make an angle equal to a given angle ABC. Draw any line EF. With centre B and any radius describe the arc AC. With centre E and same radius describe the arc DF. With distance AC as radius and F as centre cut the arc in D. Draw ED through E and D.

7. Through a given point C to draw a line meeting a given line AB at an angle equal to a given angle H. Through C draw CF parallel to AB. At C make the angle FCD equal to H, and the angle CDB will also be equal to it.

8. To bisect the angle made by two converging lines BA, DC, without using the apex. Draw a line at any convenient distance parallel to AB, and another at same distance parallel to CD to intersect in E. Bisect the angle thus obtained.

9. Through a given point E to draw a line converging to the same point at which two other converging lines would meet if produced. Draw any two convenient lines FG, HK parallel to each other and cutting both AB and CD. Join E and F, E and G. Through H draw HL parallel to FE, and through K, KL parallel to GE, intersecting at L. Draw EL through E and L.

10. In a given line AB to find a point equidistant from two given points C and D without it. Join C and D, and bisect the line CD by a perpendicular meeting AB in E, which is the required point.

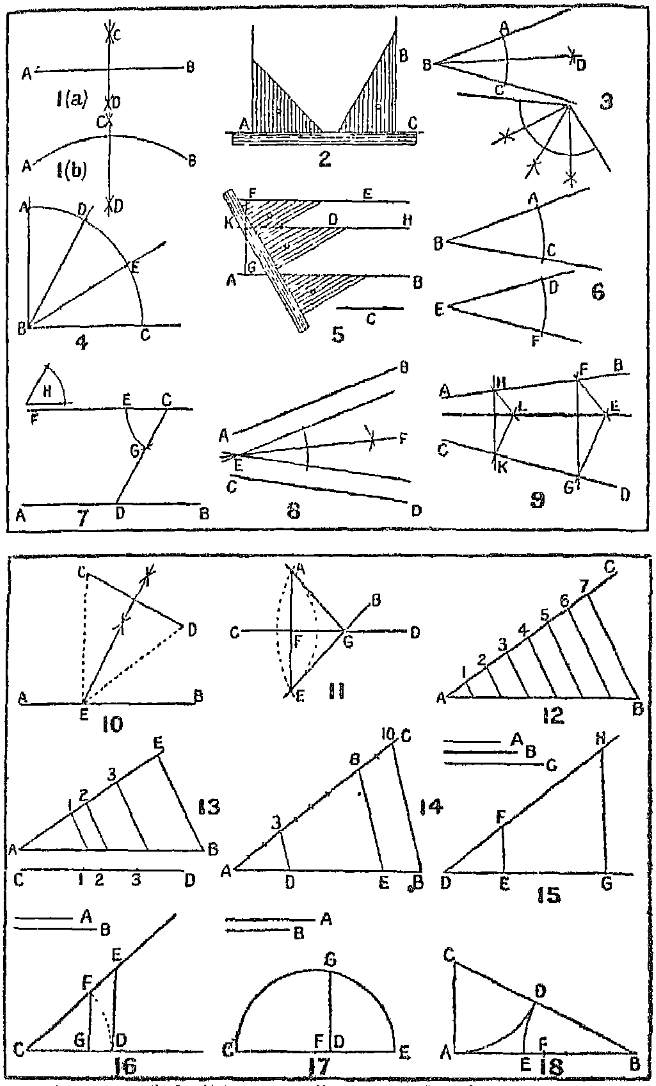
11. To draw two straight lines to meet a given line CD from two given points A and B without it, and to make equal angles with it. Draw AE perpendicular to CD, so that FE equals FA. Draw BE cutting CD in G. Draw AG. Then AG and BG are the required lines.

Proportionals. If a straight line be drawn parallel to one side of a triangle, it cuts the other two sides or those produced proportionally.

12. To divide a line AB into any number of equal parts (say, seven). Draw AC at any angle with AB, and set off on it any convenient distance seven times. Join $7B$ and from the points 6, 5, 4, 3, 2, 1, draw parallels to $7B$ to cut AB.

13. To divide a line AB proportionally to a given line CD. Draw AE at any angle with AB. Make $A1$, 1 2, 2 3, $3E$ equal to $C1$, 1 2, 2 3, $3D$ respectively. Join E and B. Draw parallels to EB through 3, 2 and 1 to meet AB.

14. To divide a given line AB in the same proportion as the Nos. 3, 5, and 2. Draw AC at any angle with AB, and set off



FIGS. 1—18. EXERCISES IN LINES ANGLES AND PROPORTIONALS

on it 3+5+2 equal parts. Join 10 and B, and through 3 and 8 draw parallels to $10B$ to meet AB. Then $AD : DE : EB$ are as $3 : 5 : 2$.

15. To find a fourth proportional (greater or less) to three given lines A, B, and C. Draw DG and, at any angle with it, DH. Set off DE equal to A, and DF equal to B. Join E and F. Set off EG equal to C. Through G draw GH parallel to EF cutting DH in H; then FH is the fourth proportional *greater*—i.e. $DE : DF :: EG : FH$. When the fourth proportional *less* is required, use the same method, but commence with the *longest* line.

16. To find a third proportional (greater or less) to two given lines A and B. This is the same thing as finding the fourth proportional to three given lines, the last two of which are equal (e.g. $A : B :: B :$ required line). Proceed as in 15, but remember B is used twice (in 16, CF and CD each equal B). CE is the required third proportional *greater*. For the third proportional *less*, commence with B and use A twice.

17. To find a mean proportional to two given lines A and B. On a straight line make CD equal to A, and DE equal to B. Bisect the whole line CE in F and describe a semicircle with F as centre and FC or FE as radius. At D draw DG perpendicular to CE to meet the arc in G. Then DG is the mean proportional—i.e. $CD : DG :: DG : DE$, or $A : DG :: DG : B$.

18. To divide a line AB into an extreme and mean ratio—i.e. so that one part shall be a mean proportional between the whole line and the other part. Draw AC perpendicular to AB and equal to half of it (AF or FB). Join B and C. Make CD equal to CA. With centre B and radius BD cut off BE. Then AB is divided at E, so that $AE : EB :: EB : AB$, or so that the rectangle AE, AB, equals the square on EB.

LESSON 24

Use of Scales in Practical Geometry

In this Lesson we are concerned with the varieties and construction of scales, so far as these relate to practical geometry. It should be emphasized at the outset that all scales must be constructed with very great care, and drawn with a very sharp pencil or fine pen to ensure absolute accuracy.

To draw a scale of $\frac{3}{4}$ in. to 1 ft. to measure 6 ft. and show feet and inches. Draw two parallel lines about $\frac{1}{10}$ in. apart. Set off $\frac{3}{4}$ in. six times, then each of these parts represents 1 ft. Divide the first part into 12 equal divisions, each of which will represent 1 in. When figuring and naming the parts it is important that the zero should be placed as shown, so that dimensions may be taken off readily with the dividers. Thus, to take off 3 ft. 8 in., place one leg of the dividers on point 3 ft. and the other on 8 in. The representative fraction is obtained thus :

$$\frac{\frac{3}{4}\text{ in.}}{1\text{ ft.}} = \frac{\frac{3}{4}\text{ in.}}{12\text{ in.}} = \frac{3}{48} = \frac{1}{16}$$

To construct a scale of $1\frac{1}{2}$ in. to 1 yd. to measure 3 yds. and show yards and feet. Draw two parallel lines as before. Set off $1\frac{1}{2}$ in. three times, and divide the first part into three equal divisions, which represent feet.

Representative fraction :

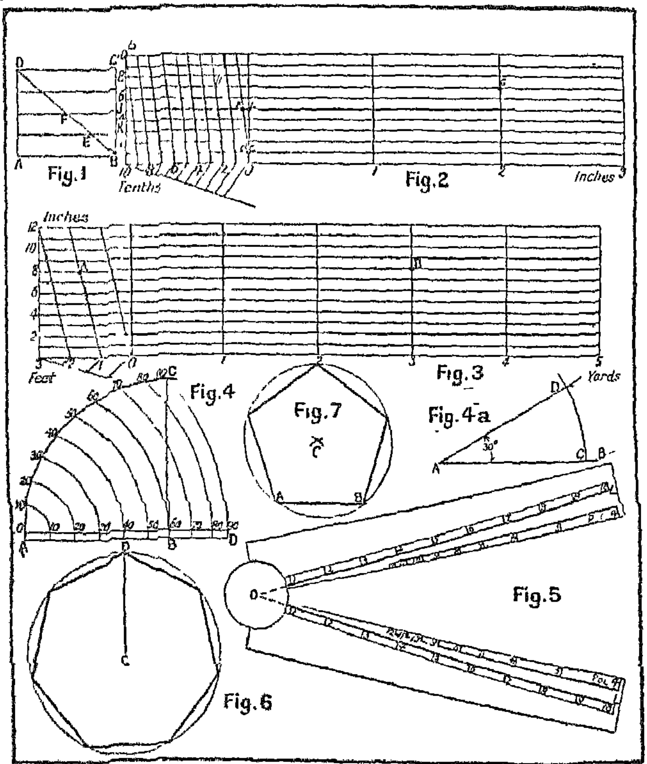
$$\frac{1\frac{1}{2}\text{ in.}}{1\text{ yd.}} = \frac{1\frac{1}{2}\text{ in.}}{36\text{ in.}} = \frac{3}{72} = \frac{1}{24}$$

To draw a scale of $2\frac{1}{4}$ in. to 1 mile to show miles and furlongs, and to measure 2 miles. Draw two lines as before. Set off $2\frac{1}{4}$ in. twice to represent miles, and divide the first part into eight equal divisions, which represent furlongs.

Diagonal Scales. These are used when the divisions become very minute. The construction is based upon the principle of similar triangles. Let the rectangle *ABCD* (Fig. 1) be divided into four equal parts by parallels to *AB*, and the diagonal *BD* be drawn, then a number of similar triangles will be formed. Thus the triangles *CBD* and *JBF* are similar ; therefore if *BJ* is half of *BC*, then *JF* is half of *CD*. In the same way *KE* is one-quarter of *CD*. As *CD* may be as small as we like, it can be easily realized how valuable this principle is From a *plain* scale we obtain two dimensions, such as miles and furlongs, or yards and feet, but from a *diagonal* scale we may obtain three dimensions, such as yards, teet, and inches.

To draw a diagonal scale showing inches, tenths, and hundredths of an inch, and to measure 4 in. Draw a line (Fig. 2) and mark off on it four separate inches. Divide the first inch into 10 equal parts for tenths of an inch, then on a perpendicular erected at 10 set off 10 equal parts to any convenient unit, and through each draw parallels to the first line. Erect

perpendiculars at 0, 1, 2, and 3, join 9 and *B*, and through each division for tenths of an inch draw the other diagonal lines parallel to 9B as shown. The distance CD is $\frac{1}{100}$, EF is $\frac{3}{100}$ of an inch, and *GH* is 2 $\frac{27}{100}$ in. or 2·27 in.



DIAGRAMS ILLUSTRATING USE OF SCALES

Draw a scale of $\frac{1}{48}$ to show yards, feet, and inches, and to measure 6 yds. This $\frac{1}{48}$ means $\frac{3}{4}$ in. to a yard, or $\frac{1}{48}$ of 1 yd.

$$= \frac{1}{48} \times \frac{36}{1} \text{ in.} = \frac{36}{48} \text{ in.} = \frac{3}{4} \text{ in.}$$

Draw a line (Fig. 3) and mark on it $\frac{3}{4}$ in. six times, to represent yards. Divide the first division into three equal parts for feet. On a perpendicular erected at 3 feet set off 12 equal parts of any

convenient unit, and through each part draw parallels as before. Erect perpendiculars at 0, 1, 2, 3, 4, and 5 yards. Join 2 ft. and 12 in., and draw other diagonals parallel to it. Figure and name divisions on scale as shown. AB represents 3 yd. 1 ft 8 in.

Scale of Chords. This is used for measuring angles, and is marked on a ruler or protractor by the letters *CH* or *CHO*. The best way to know how to use this scale is to learn its construction.

Make a quadrant ABC (Fig. 4). Divide the arc AC into nine equal parts of 10° each. The divisions 10, 20, 30, etc., on AD are found by taking A as centre with radius $A10$, $A20$, $A30$, etc., on arc AC, and marking them from A along AD as shown by concentric arcs. The distance from A to each division on AD is the chord of the angle containing that number of degrees. The divisions become smaller as they approach 90°. The distance 0 to 60 is *always* the radius of the arc to be used in making any angle. Thus, to make an angle of 30°, draw any straight line AB as in Fig. 4a. With either end, as A, as centre, and radius $A60$ in Fig. 4, describe an arc CD. With C as centre and $A30$ as radius cut CD in D. Join AD, then DAC is an angle of 30°.

The Sector. This instrument (Fig. 5) is formed of two flat legs hinged at O. Lines OL are drawn radiating from O, one on each leg, and are called *the line of lines*, by the use of which problems in proportion can be readily solved. There is also *the line of polygons*, marked *POL*. Care must be taken to measure always from points on the lines (thick in illustration) drawn from the centre O.

The following five problems show some of the uses of the sector.

To bisect a line. Open the sector until the transverse distance from, say, 8 to 8 on OL equals the given line. Then the distance from 4 to 4 is half the line.

To divide a straight line into five equal parts. Open the sector until the transverse distance from 5 to 5 on OL equals the straight line, then the distance from 1 to 1 will be $\frac{1}{5}$ of the given line.

To find x in the proportion $2 : x :: 5 : 2\frac{1}{4}$. With the dividers measure $2\frac{1}{4}$ in. Open the legs of the sector until the distance between 5 on OL of one leg and 5 on OL of the other is $2\frac{1}{4}$ in. Then the transverse distance between 2 and 2 on OL is the required distance x.

To inscribe a regular heptagon in a circle. Open the sector

until the distance from 6 to 6 on *POL* equals the radius *CD* of the circle (Fig. 6). Then the transverse distance from 7 to 7 on *POL* is the side of the heptagon.

To construct a regular pentagon on a given line *AB*. Open the sector until the transverse distance from 5 to 5 on *POL* equals *AB* (Fig 7) With *A* and *B* as centres, and the transverse distance from 6 to 6 as radius, make arcs intersecting at *C*. With centre C and same radius describe a circle. Set off *AB* round it.

LESSON 25

Proportional Scales & Construction of Triangles

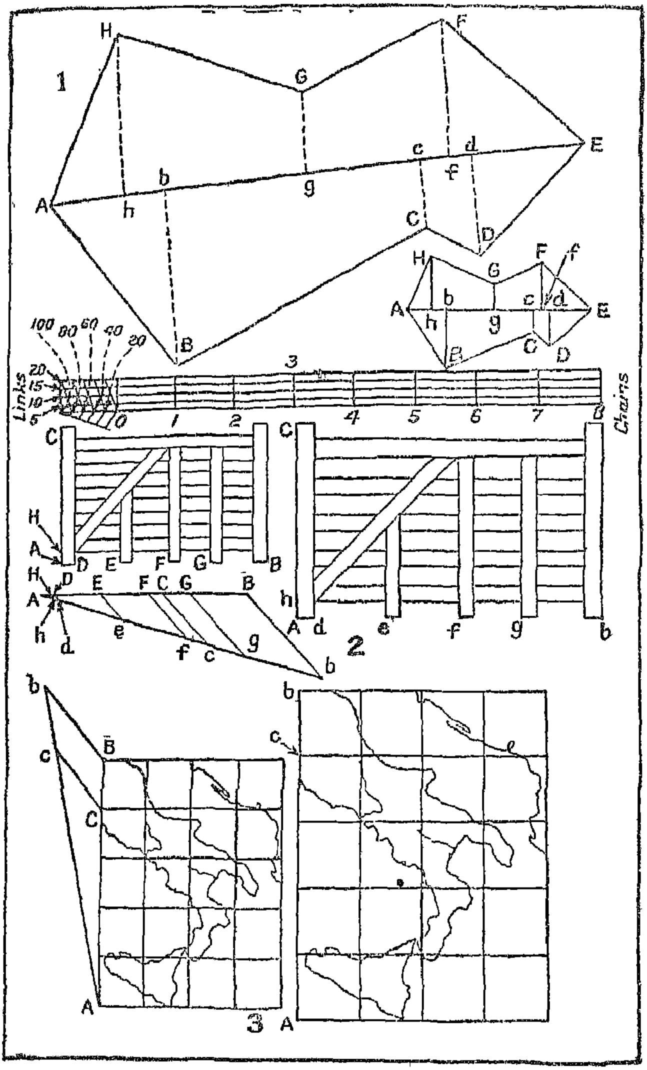
To construct an irregular polygon from a rough diagram, the dimensions on a diagonal AE, and the ordinates bB, cC, dD, etc., being given. AE=9 ch., Ah=1 ch. 30 l., Ab=2 ch , Ag=4 ch 40 l., Ac=6 ch. 30 l., Af=6 ch. 80 l., Ad=7 ch 15 l The ordinates hH=2 ch. 60 l., gG=1 ch. 25 l., fF=2 ch. 20 l., dD=1 ch. 60 l., cC=1 ch. 10 l., and bB=2 ch 80 l. Scale, ½ in. to 1 ch.

First construct the scale as shown in Fig. 1. The diagonal scale is for obtaining measurements of 5, 10, or 15 l. Draw AE, 9 ch. long, according to scale, then set off Ah, Ab, Ag, etc., on it. At the points h, b, g, c, etc., erect the ordinates according to scale. Join A, B, C, D, E, F, G, and H.

To enlarge or reduce a drawing by a proportional scale. Say, to enlarge the given drawing of a gate (Fig 2) so that AB shall be 2½ in. First construct the proportional scale by drawing the two lines AB and Ab at any angle with each other, making AB=AB and Ab=2½ in. Mark the several distances on small drawing on AB. Join B and b, and through H, D, E, F, C, and G draw parallels to Bb as shown. Then the respective measurements along Ab are the required ones for the larger drawing.

To enlarge a map. Make a proportional scale as before, and as shown in Fig 3. Set out the squares for the larger map according to enlarged scale, and then draw the map so that all parts come in corresponding positions.

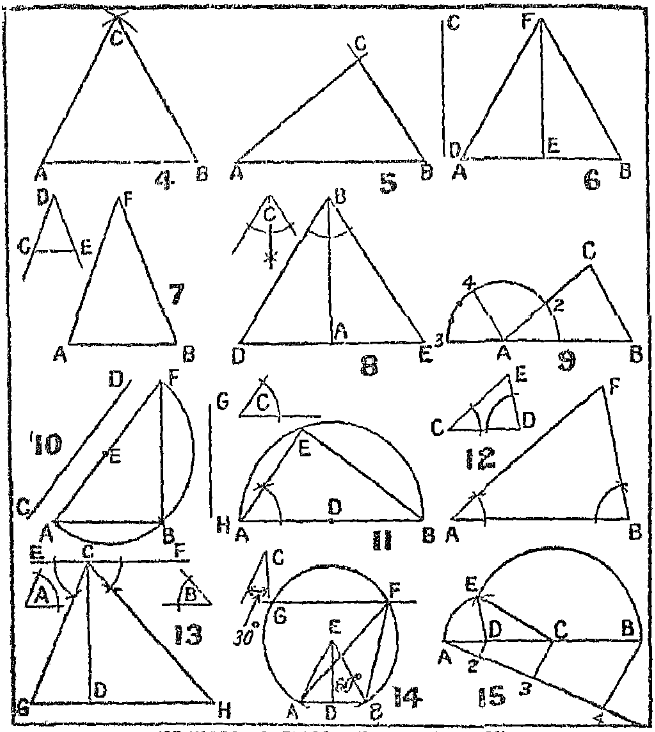
Triangles. To construct an equilateral triangle on a given straight line AB. With centres A and B and AB as radius



PLAIN AND PROPORTIONAL SCALES

(Fig. 4) describe arcs intersecting at C. Join AC and BC Then ABC is the triangle required

To construct a triangle with sides 2·5 in., 1·8 in , and 3 in. First (Fig. 5) draw one side, say, AB = 3 in. as base ; with A as centre and a radius of 2·5 in describe an arc, and with B as centre



METHODS OF TRIANGLE CONSTRUCTION

and 1·8 in. as radius, describe another arc cutting the other in C. Join AC and BC, which complete the triangle required.

To construct an isosceles triangle, the base AB and the altitude CD being given. Bisect AB in E (Fig 6) and at E erect a perpendicular EF, equal to CD. Join FA and FB Then AFB is the triangle required.

To construct an isosceles triangle having given the vertical angle CDE and the base AB. With D as centre and any con-

venient radius (Fig. 7) cut off DC equal to DE. Join CE. At A and B make angles each equal to ECD or CED. Then AFB is the triangle required.

To construct an isosceles triangle, the vertical angle C and the altitude AB being given. Draw DE perpendicular to AB (Fig. 8). Bisect the angle C. At B construct an angle on each side of AB, each equal to half the angle C DEB is the required triangle.

To construct a triangle the base AB and the ratio 2 : 4 : 3 of the angles being given. Produce AB any length (Fig. 9). With A or B as centre describe a semicircle and divide it into nine equal parts (2+4+3) Draw AC through 2. Join A4. Through B draw BC parallel to A4, meeting AC in C. ABC is the triangle required.

To construct a right-angled triangle, the base GH and hypotenuse CD being given. Take a line AF (Fig. 10) equal to CD as diameter, and bisect it in E. With E as centre, describe a semicircle FBA With A as centre and GH as radius, cut the semicircle in B. Join BF and AB Then ABF is the triangle required, and it has the right angle at B.

To construct a right-angled triangle, the hypotenuse AB and an acute angle C being given. Bisect AB in D (Fig. 11). With D as centre describe a semicircle on AB At A construct an angle BAE equal to C. Join BE. ABE is the triangle required.

On a given base, AB, to construct a triangle similar to a given triangle, CDE. Make the angles at A and B respectively equal to those at C and D (Fig. 12). Then ABF is the triangle required.

To construct a triangle, the altitude CD and the base angles A and B being given. Through C and D (Fig. 13) draw lines EF and GH perpendicular to CD. At C make the angle ECG equal to A and FCH equal to B. CGH is the triangle required.

To construct a triangle, the base AB 1·75 in. long, the vertical angle C 30°, and the altitude 1·5 in. being given. Bisect AB in D (Fig 14) and erect a perpendicular at D. At either end of AB make an angle of 60° (90°—angle C, 30°), intersecting the perpendicular at E. With centre E and radius EA draw the arc ABFG. Draw FG parallel to AB and 1·5 in. from it. Join FA and FB. ABF is the triangle required. The angle at the centre is always twice the angle at the circumference, thus, the angle AEB is twice the angle AFB.

To construct a triangle whose perimeter shall be equal to a

given line AB, and the sides in the proportion 2 : 3 : 4. Divide AB (Fig. 15) in the proportion 2 : 3 : 4 as shown. With D and C as centres, and DA and CB as radii respectively, describe arcs intersecting at E Join DE and CE. Then EDC is triangle required

LESSON 26

Quadrilaterals and Regular Polygons

OUR last Lesson dealt with the construction and use of scales and the construction of triangles In this Lesson we proceed to the construction of four-sided figures or quadrilaterals and of regular polygons.

1. To construct a square, the side AB being given. At A and B erect the perpendiculars AD and BC respectively, each equal to AB. Join CD

2. To construct a square, the diagonal AB being given. Bisect AB by the perpendicular CD With centre E and radius EA, describe a circle cutting CD in C and D. Draw AD, DB, BC, and CA.

3. To construct an oblong or rectangle, the two sides AB and CD being given. At A and B erect the perpendiculars AF and BE respectively, each equal to CD. Join EF.

4. To construct an oblong, the diagonal AB and one side CD being given. Bisect AB in E With centre E and radius EA describe a circle With centres A and B and radius CD cut the circle in G and H on opposite sides of AB. Join AG, GB, BH, and HA.

5. To construct a rhombus, the side AB and one of the angles C being given At A make an angle equal to C, and make AE equal to AB. With centres B and E and radius AB describe arcs intersecting at D. Join BD and ED.

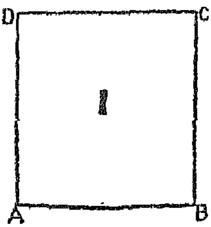
6 To construct a rhombus, the diagonal AB and one side CD being given. With centres A and B and radius CD describe arcs intersecting at E and F. Join AE, EB, BF, and FA.

7 To construct a rhomboid, the two sides AB, CD, and an angle E being given. Draw FG equal to CD At F make an angle equal to E. Make FJ equal to AB. Through J draw JH parallel to FG, and through G draw GH parallel to FJ, cutting JH in H,

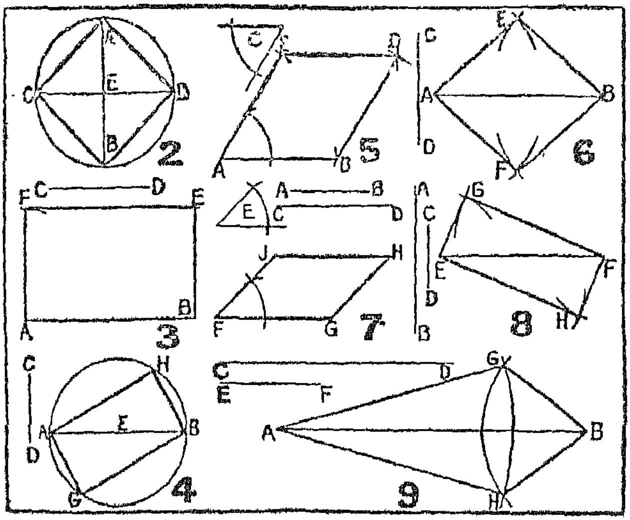
8. To construct a rhomboid, the diagonal EF and the two sides AB and CD being given. With centres E and F and radius AB describe arcs on opposite sides of EF. With the same centres and radius CD, describe arcs on opposite sides of EF intersecting the first arcs in G and H respectively. Join EG, GF, FH, and HE.

9. To construct a trapezium, the diagonal AB and two pairs of equal sides CF and EF being given. With centre A and radius CD describe an arc. With centre B and radius EF describe another arc intersecting the first in G and H Join AG, GB, BH, and HA.

Regular Polygons. There are general and special methods of constructing these polygons. The general methods, as in Figs. 10, 11, and 16, apply equally to all polygons, but in particular polygons the special method is sometimes shorter and more accurate, as in Figs. 12, 13, and 14. The following are important facts concerning *regular* polygons:



i. Lines which bisect the angles of regular polygons meet in one point,

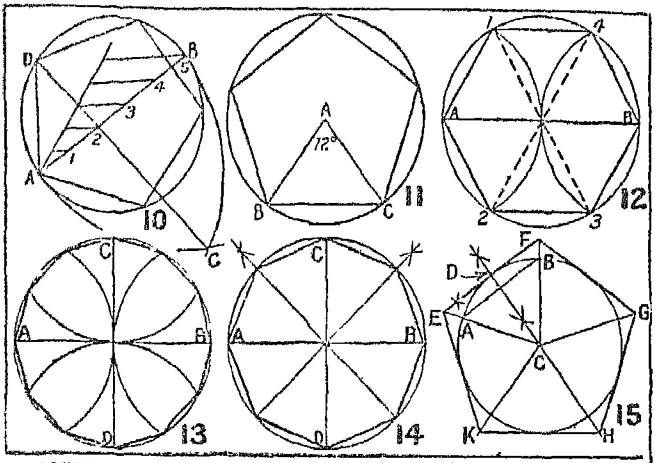


CONSTRUCTION OF QUADRILATERALS

which is the centre of the figure, and they divide the polygon into a number of equal triangles. In the hexagon these are equilateral (Fig. 12), but in all other regular polygons they are isosceles (Figs. 14, 15).

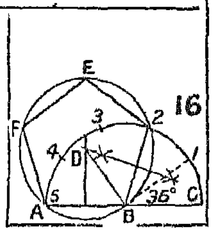
ii. The centre of the polygon is the same as that of the circle to which the sides of the polygon are tangent (the *inscribed* circle) and also of the *circumscribed* circle which passes through the angular points (Figs. 10–16).

iii. The sum of all the interior angles of a regular polygon plus four right angles is equal to twice as many right angles as the



CONSTRUCTION OF REGULAR POLYGONS

figure has sides. This affords a ready method of constructing any regular polygon by means of the protractor when the side is given—a fact made use of in surveying.



10. In a given circle, to inscribe any regular polygon (Approximate Method). Draw the diameter AB and divide it into the same number of equal parts as the figure has sides (say, five). With A and B as centres, and AB as radius, make arcs intersecting at C. From C draw CD, *always through the second division on* AB, cutting the circle in D. Join AD, which is one

side of the pentagon required. Set off AD round circle and join points as shown.

11. Another Method. Draw any radius AB. At the centre A make an angle with AB equal to 360° divided by the number of side of the regular polygon required; say, a pentagon.

Thus, $360° \div 5 = 72°$. Therefore, make the angle $BAC = 72°$. Join BC, which is one side of the pentagon. Set off BC round the circle, and join the points as shown

12. To inscribe a regular hexagon in a given circle (Special Method). Draw any diameter AB. With centres A and B, and radius equal to that of the circle, cut the circle in 1, 2, 3, and 4. Join the points as shown.

13. To inscribe a regular duodecagon in a given circle (Special Method). Draw two diameters AB and CD perpendicular to each other. With centres A, B, C, and D, and radius equal to that of the circle, describe arcs cutting the circumference of the circle. Join the twelve points as shown.

14. To inscribe a regular octagon in a given circle (Special Method). Draw two diameters AB and CD as in 13. Bisect each quadrant thus formed. Join the eight points thus obtained.

15. To describe any regular polygon about a given circle (General Method). Divide the circumference into as many equal parts as the figure is to have sides (say, five for a pentagon). From the centre C draw lines through each point. Draw AB, one of the sides of the inscribed pentagon. Bisect AB by the perpendicular CD, cutting the circumference in D. Through D draw the tangent EF parallel to AB, cutting CE in E, and CF in F. Make CG, CH, and CK each equal to CE or CF. Join F, G, H, K, and E as shown.

16. On a given line AB to construct any regular polygon (General Method). Produce AB, and with centre B and radius BA describe a semicircle, and divide it into the same number of equal parts as the figure has sides (say, five). Join B with 2. Bisect AB and B2 by lines intersecting at D. With D as centre and radius DA or DB, or D2, describe a circle. Set off AF and FE each equal to AB. Join the points thus obtained.

In this construction divide semicircle with the protractor. As there are 180° in a semicircle, divide 180° by the number of sides the polygon will have; thus, $180° \div 5 = 36°$. Then make the angle CB1 equal to 36°, and mark off C1 round the semicircle.

Our Course in Drawing and Design is continued in Volume 5.

LESSON 7

Meat and Milk as World Products

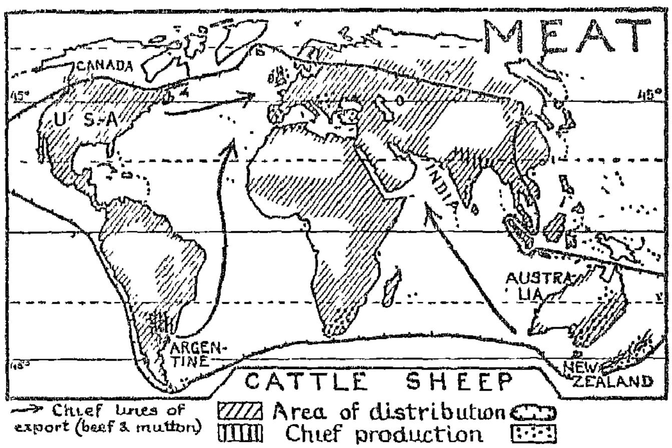
MEAT and milk enter into world trade in response to two circumstances The first, on the productive side, is the need for some means of turning vast expanses of grass-land in less populated areas into property, the second, on the side of consumption, is the necessity of providing for the world's workers foods suited to their expenditure of energy

The great grass lands of the world are of two kinds both lack sufficient moisture for the growth of trees—the one having a snow cover in winter and the other warmish but arid winters Both occur on a dry side of a forest region, the cold grass-lands, known as prairie and steppe, are on the warm equatorial side of the cold coniferous and deciduous forests, and consequently penetrate into the forest clearings, the warm grass-lands—veld, pampas, and downs—lie on the cool side of the equatorial forest, between the forest and the hot desert

Until comparatively recent years the prairie, the pampas, and the downs, in North America, South America and Australia respectively, were open spaces relatively without population. On ranges, haciendas, and sheep runs, settlers let animals roam wild. On the ranges cattle were preferred to sheep, on the downs sheep were preferred to cattle Grazing rights, water rights, access to trails to market, and other circumstances led to the delimitation of sections of grass-land as the property of a stock-owner and the land became property, with a value as a potential feeding ground for so many head of animals Much grew to more and property in land, and the animals which it sustained, led to property in animal produce Slowly the interest of the stock-owner charged from attention to the mere disposal of a surplus product due to a bountiful Nature, into careful planning with a view to the capture and retention of markets for the sale of stuff deliberately produced for sale This resulted in the deliberate fencing of the ranches and the consequent improvement in the breed of the animals reared

This advance was accompanied by a definite extension of railway and shipping facilities, for while animals may travel

"on the hoof" to market, modern requirements demand a regular supply, which hoof transit cannot maintain, coupled with a quality of condition on arrival which the travelled animal cannot show Further, the change has involved reorganization to maintain a regular demand for a regular output This has meant the use of devices for dealing with a surplus or glut of supplies, with the consequence that most of the transport is now in the form of meat and not in that of living animals, to accomplish this development required the invention of mechanical methods of canning and preserving meat, and led to the general adoption of meat packing and refrigeration Meat packing is a prairie device, refrigeration was a New Zealand expedient. An expansion of this business—which is a factory operation—is the



trade in tinned milk, meat extracts, etc., whereby much nutriment is conveyed in small bulk

Concurrently with this steady growth, which has now reached the stage when the producer of meat is anxious to cajole the buyer into extravagance in meat consumption, there has been in western Europe the slow development of farming on small areas, merely, in the main, to satisfy local needs. The great rancher has tried to create a market in the face of local supplies. By advertisement, by constant attention to improvements in the quality and allurement of his product, and by a definite underselling, he has endeavoured to guarantee his sales. The

ranching business has grown, because the increasing manufacturing peoples of Europe have enlarged their consumption of meat. The rancher, however, has had his own difficulties. The arable farmer has steadily ousted him from lands which were of yore near to the markets, and these have now been turned into wheat farms; so that the world—i.e. the western world—has to face a glut both of cereals and of meat, and the consumers cannot enjoy this surplus because the transport costs prohibit movement. Cost of production is out of harmony with cost of transport, and movement of supplies is curtailed.

Some Cattle Statistics. The situation may be gauged by some reference to the numbers of cattle which enter effectively into the meat trade—the cattle of India, which number over 100 million head, may be ignored in this connexion. Excluding Russia, which has 50 million, there are 100 million cattle in Europe of which some 60 million are located on the great European plain, i.e. in Germany, France, Belgium, the Netherlands, Denmark and England. Two-thirds of the rest are in central Europe. From these cattle comes the local supply of beef and milk. This supply reaches those industrially centred markets where the people are wealthy enough—in consequence of the relatively high wages of the factory worker in comparison with the land labourer—to enjoy a diet of meat and milk and wheat. Some 70 million head occupy the prairie ranches. These provide a local supply for the factory workers, etc., of North America and a surplus for export: but the main surplus for both the western European and North American markets comes from the 70 million cattle of Argentina and Brazil. This means that meat prices will tend to be controlled by the conditions in South America. There are some 15 million cattle in Australasia, but this number is not enough to weight the scales against South American dominance in the world's meat market.

Dairy Products. The milk product enters into long-distance traffic as condensed or dried milk, butter and cheese. Trade in butter is simple; in general, local supplies meet local needs. Otherwise only Britain and Germany are importers; they are supplied by Denmark and New Zealand, with the assistance of Australia and the Netherlands. Trade in cheese is almost equally straightforward. As in the case of butter, Britain is the chief buyer; then come Germany, France, Belgium and the United States. The Netherlands and New Zealand are the chief

sellers; then come Canada and Italy. Britain buys more of each commodity than all the other countries together.

On the whole, cattle are suited to a wider range of conditions than sheep, for example, cattle thrive in the warm grass-lands of Brazil, in the cold grass-lands of the prairie, and in the humid cool land of Denmark, as well as in Switzerland, with its tinned milk and milk chocolate industries. The difference in range between sheep and cattle may be noted in Australia, where the sheep are excluded by excessive heat from the northern districts and shut off from the wetter coasts of the east, where the dairy cattle flourish, in western Europe, where France has more sheep than cattle, Germany more cattle than sheep, Denmark and the Netherlands very few sheep, and where Britain has the largest numbers of sheep of all.

Mutton and Bacon. Consideration of the distribution of sheep involves attention to wool as well as mutton. The predominant importance of the 100 million sheep in Australia rests on wool, but the 30 million head in New Zealand and, also, in Britain are for mutton as well as wool. There are some 40 million in Argentina and, roughly, the same in South Africa, but the mutton trade is more important in South America. The mutton supplies of Britain and western Europe come mainly from the southern hemisphere, for the 50 million sheep of the United States do not supply much mutton to Europe. The production and trade in pork and bacon, etc., is more localised than the other meat produce. Pigs are limited in America to the United States, 60 million, and to Brazil, 16 million; and in Europe to Germany, 24 million, and 16 million in Denmark and France. Britain has fewer pigs than Denmark. Pork and beans is an American dish which consumes the local supply. Bacon, etc., are products of the dairying industry with which they are associated; hence the pigs in Denmark, where they are four times as numerous as they are in the Irish Free State. In the United States the rearing of pigs does not depend on the cattle, but upon the circumstance that maize is predominantly grown in large measure in the corn belt of that country on the warmer prairie land. Finally, the trade in eggs merits a little attention. It is, in the main, closely related to the dairying industry, for Britain and Germany are the chief buyers of foreign supplies, and Denmark, the Netherlands and Poland are the principal exporters, with the Irish Free State next.

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LESSON 8

The Ocean's Contribution to Human Welfare

To Britons there is romance in the fisheries. The thought of the trawlers on the Dogger, the dories on the Grand Banks, the whalers amid the ice floes, suggests bravery, fortitude, continuous conflict with harsh Nature and continuous victory; it thus stirs the pulse to admiration of those who reap the harvest of the deep waters. The urge that persisted throughout Europe during many centuries to supplement a meagre diet of flesh, which became unappetising as the winter wore on, with a weekly meal of fish caused hardy fishermen, who *sailed the Atlantic in mere cockle-shells, to make the ocean a* highway to Nature's stores. Bretons and Britons frequented the Grand Banks; Scots and Scandinavians, among others, sailed the seas to the south—and all sought fish.

It is still an item of news that the Scottish fisher girls make their annual pilgrimage along our eastern fishing ports to gut the herring and pack the salted fish. Modern conditions which provide the trawlers with tenders to deliver the catch, which supplement the barrel of salted fish with the canning process, which provide a railway service for the rapid delivery of perishable fresh fish for the food of millions of factory hands, have not withdrawn the romance that pertains to fish.

The fishery seems, at first sight, to be one of the occasions when a bountiful Nature yields the toilers something for nothing. Possibly in the old days, when fish had no important competitors as an article of diet, it was true that the fisher's catch was a lucky strike and not a reward of patient forethought. This may still be true in primitive communities, but nowadays the fisherman is not a mere marauder. Failure often comes that way The tons of fish which it is necessary to catch to make the fisheries pay their way in competition with other industrial undertakings are not found by chance. The fish must be sought when and where they occur in gigantic shoals, or they must be awaited in areas which they habitually frequent at certain times. The

fisher is now selective; all is not fish that comes to the net. In the interests of the future the maturity of the fish abstracted from the sea is vital; in the interests of the market it is not worth while to load the boat with fish which cannot be sold, for the consumer of fish tends to be very conservative.

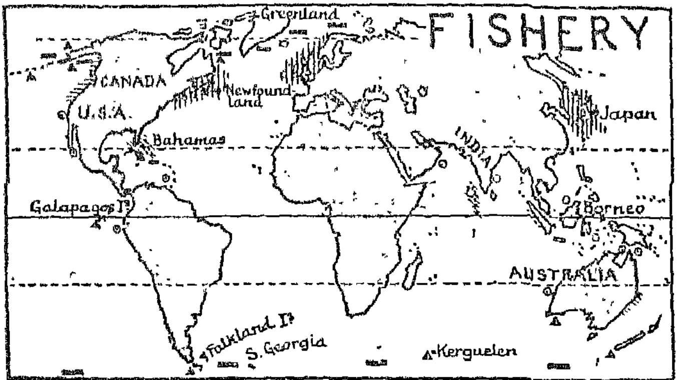
Two Great Fisheries. Obviously, then, fishery must be organized with the same care as any other commercial undertaking. There are only two major sea fisheries: the Grand Banks off Newfoundland and the British and Norwegian seas. Both are due to a single phenomenon. Were there no Gulf Stream, distributing waters warmed by tropical suns as far north as the edge of the cold ocean currents, which bring melted sea ice and floating sea ice towards the warmer latitudes of the Atlantic Ocean—in other words, were the north Atlantic basin of any other configuration, the deep-sea fisheries would be elsewhere, if existent. Fish food, which consists of minute organisms, is plentiful and thrives where warm waters melt cold ocean currents: food fish are plentiful where fish food abounds. Obviously, the latter is distributed in the sea waters seasonally, for both the contributory types of ocean current are seasonal in their range and intensity; consequently, the fishery is a seasonal business, and the height of the fishery season varies in different areas. The herring fishery maximum comes down the North Sea as the summer advances, and feverish activity prevails at the east coast fishery centres from Wick to Yarmouth in succession.

Organization and Marketing. This leads to the question: how is the fishery managed? The fish reach the land in gluts or spasms. The whole fishery organization is controlled by this fact, for too great a catch means too cheap or even valueless fish. The boats must be handy, quick in movement, and certain. Once caught, the fish must be landed quickly. Hence the use of steam trawlers; but this necessitates coal or other fuel, and means that the overhead charges on the industry tend to increase; fishery is therefore a business in which it is necessary that capital be invested.

At the port the landed catch must be handled expeditiously. Sufficient labour must be available to prepare the fish for the market. Hence the process of gutting and salting preliminary to packing in barrels for long-distance transport; the processes of packing in ice as perishable goods for almost immediate sale;

the processes of curing or smoking for preservation; the most modern processes of hygienic canning for preservation more or less indefinitely. Despite the fact that the port organization is well developed for these purposes, it sometimes happens that the catch exceeds the capacity of the port and fish is wasted.

Probably the most important aspect of the fishery is not the actual business of catching the fish but the marketing of the catch. The port must be in intimate touch with the markets. Hence the transport by sea, rail, or road must be adequately organized to deal with seasonal and intermittent rush traffic.



CHIEF FISHING GROUNDS Cod Herring (chief fishing grounds only) Salmon Whale Seal Sponges Pearls

But no market can be indefinitely expanded at will, hence the port organization must be in close touch with the markets in order not to send them an overstock; and the prime business at the port is the extension of the marketing area, which means an even greater development of transport. The fishmonger's exhortation to "eat more fish" is merely thrashing the air unless the fishery organization is adequate to supply the requisite fish in a steady commercial stream. Obviously the fishery is both dependent upon and due to the development of a high state of organization in a numerous and highly-organized commercial community. It is not an accident that the exploitation of the two great fishery grounds occurs near the two great populous industrial and commercial communities of western Europe and eastern North America.

Associated Products. Deep sea fishery depends, in the main, upon herring, cod and halibut. The other fish—mackerel, pilchard, sole, plaice—are accidental concomitants. Cod-liver oil has long been a valuable product; it is a recognized source of the essential vitamins A and D. Herring, in season, have always tended to be a cheap but highly nutritious food; kippers and bloaters are favourite smoked variations. Associated with these is the trade which has grown rapidly in sardines and brisling, etc., canned in olive oil, and the fish pastes potted, tinned or glassed as delicacies and alternatives for jams and confectionery.

The fish oil industry has always included whale oil as well as oil from cod and herring—either true herring or menhaden (a species of shad found off the east coast of the United States). Whales are sought usually in the colder oceanic waters.

Fisheries of the Pacific. It might be anticipated that fisheries would develop in the North Pacific Ocean along the eastern and western shores in comparatively similar localities to those of the North Atlantic Ocean; for off Japan and British Columbia the oceanic waters are similarly related to the warm current off the Pacific Ocean, the Kuro Siwo or Black Stream of Japan. Such an expectation tends to fail because the Pacific fish are neither herring nor cod. On the American coast, however—in Alaska, in British Columbia, and in the neighbouring areas of the United States—the fish are salmon, which frequent the seas and the rivers, and are most easily caught in the rivers, the Fraser and Columbia rivers and Kodiak Island are familiar names to consumers of tinned salmon. Here, again, the fishery has called for a substantial organization. The fish are caught automatically in the rivers when the shoals prevail, and the product—tinned salmon—is boxed ready for transport after manufacturing processes, most of which are mechanical.

Oyster, crab, and lobster fisheries were originally local. The canning industry, for ever seeking fresh foodstuffs for its tins, has given to the shell-fishery a wider market. Caviare from the Caspian, sponge from the Mediterranean and the Bahamas, pearls from the Orient, constitute local fisheries for the production and marketing of luxuries.

LESSON 9

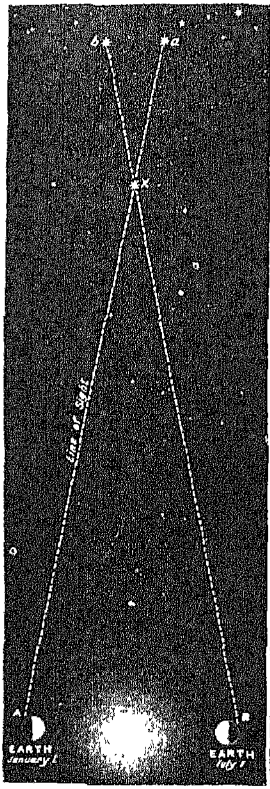
The Staff of Life in the Orient

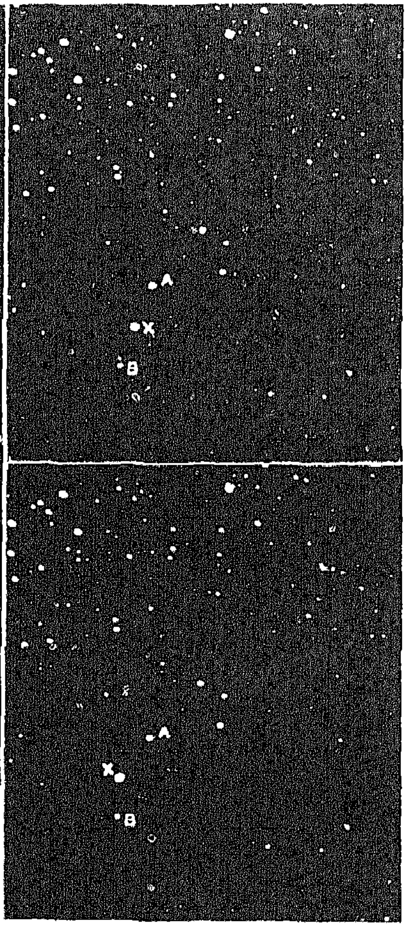
PADDY fields—the term conjures up pictures of the romantic Orient. A flat valley floor laid out in chequer-board style, with the spaces, squares or rectangles, of water-covered mud, and the lines, the separating mounds of drier mud; coolies lightly clad, with heads shielded from the sun, bending over the plants as they work ankle-deep in the mire; or a firefly flitting over a Japanese vale, which resolves itself upon closer inspection into a peasant brushing insects from his precious rice plant with a camel-hair brush by the light of a pendant paper lantern. Paddy, or padi, is rice in the husk.

Rice differs from the cereals of western Europe in that it is native to Asia and Australia. It is deficient in bread-making qualities, and is used either baked or boiled and unleavened. It is aquatic in its habit, and requires water protection during growth. Its by-products are an intoxicant, saké, in Japan, starch in the west, cattle food from the offal, plait from the stem.

Chief Rice-producing Countries. About two-fifths of the world's rice is grown in British India and adjacent Burma, where the yield of the Irawadi valley is extensive and important for export purposes. Japan comes next with a twelfth; then Indo-China and the Dutch East Indies (Java), each with 4%, and Thailand (Siam) and Korea next, each with 2%. These values ignore the production of China, about which there are no reliable figures. If it may be assumed, as is possible, that the yield in China equals that of British India, then these values should be reduced by about a third.

Rice is largely consumed locally; vast quantities are imported and exported for the inter-trade of Asiatic countries, and much smaller amounts for the rest of the world. The exporters are: first, India and Burma, with 10 parts; French Indo-China, Korea, and Thailand, each with 5 parts; Formosa, 2 parts, and Malaya, 1 part, leaving the rest of the producers with 2 parts between them, making a total of 30 parts. The Asiatic importers are: Japan, with 8 parts; Malaya, with 5 parts; China, with 4 parts;

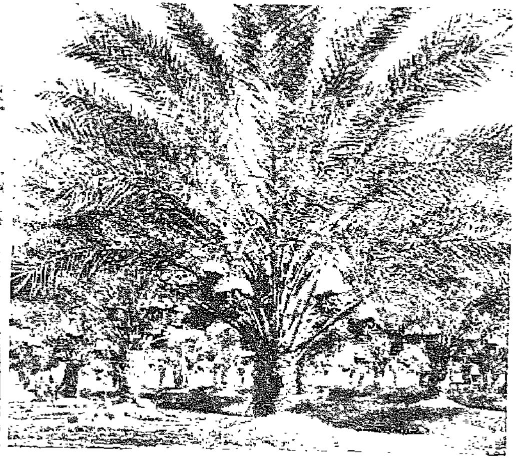




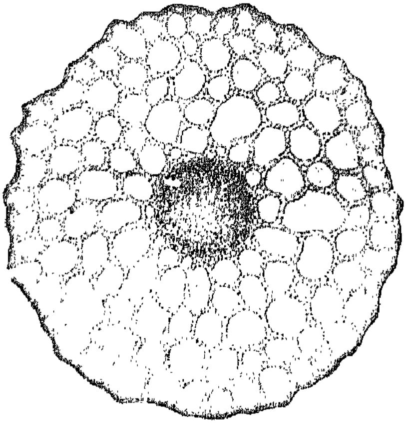
MEASURING THE DISTANCE OF THE STARS. These diagrams show two methods adopted by astronomers for determining star distances. In the left diagram, star X when observed from A on January 1 appears, in relation to the *much more distant stars*, to be at a. By July 1, when the earth is at B at the other side of its orbit and 186,000,000 miles distant from A, star X will appear to be at b. The distance A X can then be calculated. The second method (right) is more accurate. A photograph (top) of a portion of the heavens is taken through a powerful telescope at the beginning of a six months period. A second photograph taken at the end of the period, when the telescope has been carried by the earth to a point 186 million miles distant, shows an apparent movement of the star marked X relative to those marked A and B and the fainter stars in the background. Calculations based on this difference give the star's distance in parsecs. Note that the star pattern in the background remains unaltered, so remotely distant are its components. ASTRONOMY 27.

FLOWERS OF DICOTYLEDONOUS PLANTS. Left, perpetual flowering carnation, a plant of the order Centrospermales. Right, double scarlet geranium, one of the pelargonium family. BOTANY 23

TWO MONOCOTYLEDONOUS PLANTS. Left, reed mace, commonly known as the small bulrush, a hardy aquatic perennial herb, bearing brown inflorescences. Right, bee orchis, a British wild orchid. BOTANY 24

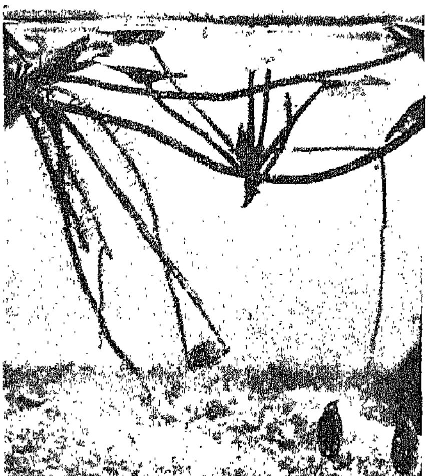


MONOCOTYLEDONOUS FRUIT-TREES. Left, leaves and fruit of *Musa sapientum*, the tropical tree-like herb better known as the banana. The leaves are oblong and very long, and the flowers red and yellow; the height of the plant is from 4 to 10 feet. Right, date palm (*Phoenix dactylifera*), a native of N. Africa. The tree attains a height of over 100 feet, the feather-like leaves being upwards of 12 feet in length. BOTANY 21



FLOATING STEM OF WATER PLANT. Section of stem of the common marestail, showing the air cavities which allow the stem to float. BOTANY 25

Photo John J. Ward

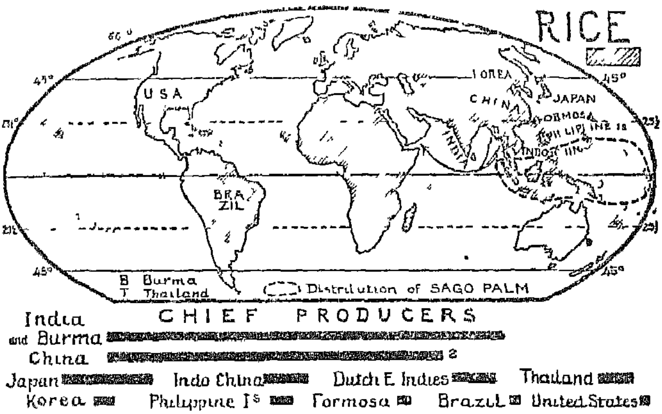


HIBERNATING BUDS. The frogbit, a floating plant, has long stalks which develop winter buds. These break off and hibernate at *the bottom of the pool,* while the surface plant perishes. Two buds are shown detached. BOTANY 25

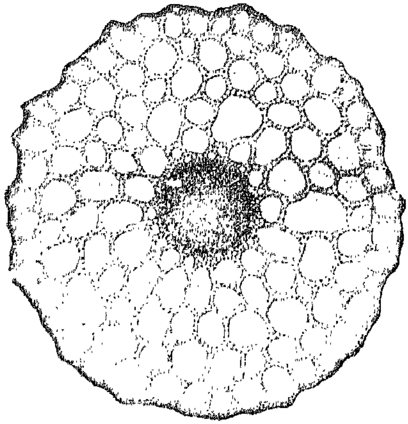
Photo, John J. Ward

Ceylon and the Dutch East Indies each with 3 parts. This makes a total of 23 parts, roughly three-quarters of the total, leaving the rest for western Europe and the West Indies, mainly Cuba. The importers in Western Europe, beginning with the largest buyer, are Germany, France, Holland, Britain, Poland.

A typical producing area is Bengal. Patna rice is a trade name. At least half the cropped area is devoted to paddy. There are 100,000 square miles of stoneless soil unbroken by any elevation —practically treeless black alluvium of superabundant fertility, continually enriched by riverine floods. In Bengal the needed water is supplied by the monsoon rains, which come with a 'burst' usually in mid June, and continue in a succession of



cyclones penetrate the Ganges lowland from the Bay of Bengal, reach a maximum in July and August, falling away in September and finishing in October; during this period a soaking soil steams between the downpours under a scorching sun. The rains may be localized in the area and patches may be dry, so that in September, which is a critical time, the plants may lack water and shrivel in the increasing dryness of the air. If water cannot be supplied from irrigation channels the crop fails. The main crop, so-called winter rice, is reaped from November to January; a smaller crop of early rice is cut between July and September, and a coarse spring rice is obtained in April. This cropping is related to the three seasons. The hot season, March to June, is useless; the wet season, June to October, supplies the water,



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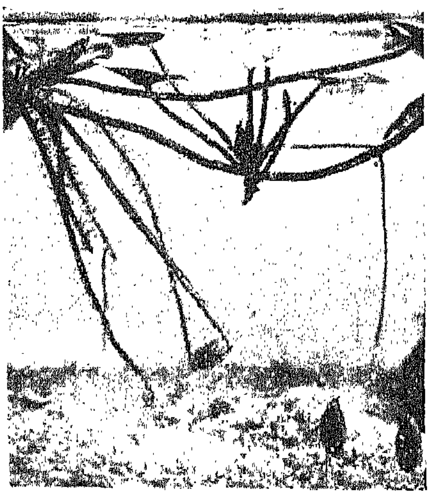

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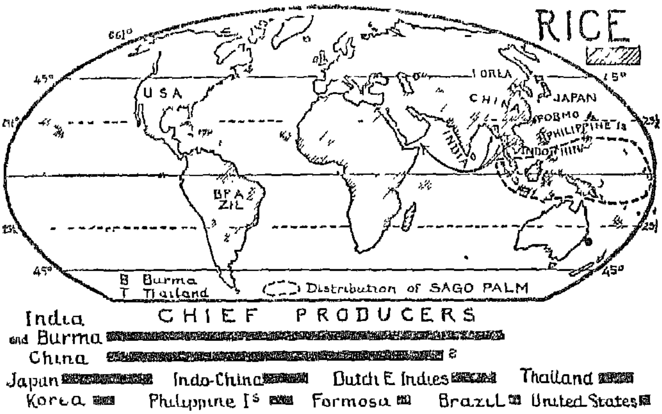

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and the cool season, November to February, is the reaping time for the main crop.

In India an inferior rice is grown on terraced irrigated hill-sides. In Japan, where lowland is strictly limited, the hill-sides are utilized for crops of superior quality, and Japan exports some better quality rice in exchange for larger quantities of cheaper rice.

Food Grains of the East. It is a mistake to suppose that rice is the sole or even the chief food grain of the east; the gigantic crops which are grown in the extensive suitable areas are insufficient for the teeming millions of the flood-swept alluvial plains of the Ganges and the Yangtze. Even in Bihar, a neighbour of Bengal, most of the people live on cereals—maize, wheat and barley, or on pulses and millets. The millets are rainy season crops, and the pulses, such as gram, are cold season crops. In the Punjab the chief food grains are wheat, gram and bajra, and millet; rice comes fourth on the list. In Madras—where about four-fifths of the cultivation is devoted to the food-grains—rice, though the chief cereal grown, is only a quarter of the supply Next comes millet, followed by red ragi (raggee), a cultivated grass. In Japan soya beans are a staple food.

The *preparation of rice* is not dissimilar from that of wheat The first process is the separation of the grain from the stalk, and in India employment is provided for some of the many millions of cattle in treading the grain out on a threshing floor. The winnowed clean paddy is then husked; the husk is used in Burma, for example, as a fuel or for the manufacture of producer gas. Bran is then removed from the rice by a process of skinning the bran being utilized for cattle food. The skinned rice is now white, and is polished for the European market. Outside the east, rice is grown in the valley of the Po, in Italy, and in the swampy areas near the delta of the Mississippi in the United States.

Sago, a somewhat similar article to rice in the British diet, comes from the East Indies. Borneo and the neighbouring islands produce this farinaceous food, which is made from the pith of an indigenous palm. The preparation is simple and is the work of natives; the yield per tree is enormous. Singapore is the chief collecting centre for the mediocre trade in sago, which is used by the manufacturers of starch and cocoa.

Rice paper is normally not produced from rice, although some

paper is made from rice straw in Japan. Rice paper is made from the pith of a shrub which grows wild in Formosa; the shrub attains a height of about 8 feet, and the sheet of paper is shaved from the pith.

Food Crops of China. Despite the unreliability of the information concerning China, some reference to that country is imperative. Rice does not enter into the economy of northern China, the land of the yellow River; there wheat and millets, with the inevitable soya bean—sometimes called the "universal food provider," so rich is it in nutriment—are the food sources. In central and southern China, the lands of the Yangtze and Si rivers, possibly two-thirds of the people rely almost entirely on rice. Cultivation is of the most intensive character. The flooded land is heavily manured with animal and human excreta specially prepared during several months; it is utilized for catch crops, while the young plants are growing in nursery fields; the transplantation is tedious, being stem by stem. Every square foot of available soil is used.

In some of the rice-eating areas there is a population density of over 6,000 per square mile, i.e. about 10 to the acre, and these folk live on what they grow. In famine years they starve, because, for many reasons, trade, even for famine-stricken districts, is almost impossible. In good years there is a glut, as they make no attempt to sell the surplus; the peasants will steadily overeat to the extent of twice as much rice as they need. Obviously, there is no saving, no margin of livelihood against the lean years. Ten to the acre is an excessive density of population for a folk which subsists on the produce of its own fields.

LESSON 10

Sugar's Place in World Economics

THE economic conflict between the produce above ground of the steaming tropical soils under a sultry sun and the yield below ground from the temperate soils in a dank atmosphere under a watery sky, is exemplified in the relative use of rice and potatoes as human foods; it becomes definitive in the struggle between the sugar cane, which is a cultivated tropical grass, and the sugar beet, a temperate root crop, to supply the world's demand for sweetness.

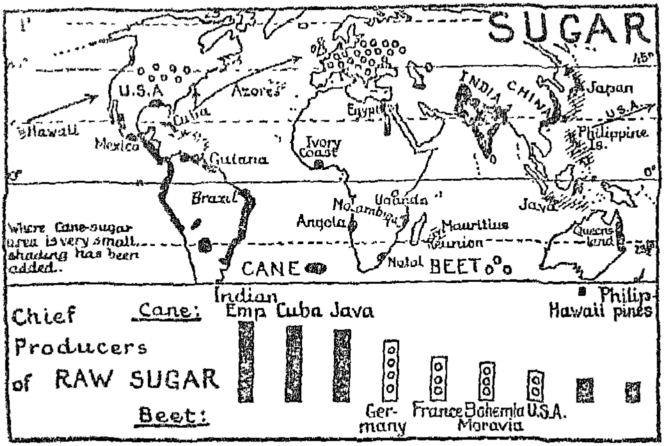
The sugar cane is productive in the areas suitable for the extensive growing of rice, being cultivated in a great heat in moist soils; it differs from rice in that its stem is the source of the commercial product and its root is perennial. Under favourable conditions it may be productive for thirty years, though five years is the usual limit. The sugar beet can be grown effectively where potatoes yield well, and is a welcome addition to the possible harvests on the poorer soils of western Europe, where cattle are reared and wheat is not successful; the refuse from the sugar factory provides stock-feed.

The production of sugar for the European markets is an organized business Its varieties, in form, are loaf or granulated; in colour, white, yellow or brown: in texture, crystalline or powdered. All varieties indicate the necessity for factory operations, while the processes of extraction and treatment of the juice require operative skill and expert chemical knowledge. There is a vast difference between a modern beet sugar factory of the type recently established in East Anglia and the crude arrangements which prevail in southern India, where sugar canes are a feature of the landscape. There a pair of bullocks attached to a pole amble in a wide circle to cause a rotation of rollers which press the juice from the canes; the whole proceeding takes place in the open air, with its consequent dirt and dust. This native industry produces jaggery or raw sugar, country sugar and molasses mainly for local consumption, and the quantity is difficult to enumerate. Such tropical and typical crudity is in striking contrast with the conditions in the lone island of Mauritius, which depends for its existence almost entirely upon its export of sugar. There the cane sugar has dominated the settlement of the island, its changes in population—for it has required the importation of labourers—the construction of its roads and its railways.

Beet Sugar Industry. The industry connected with sugar beets is little more than a century old and depends almost entirely upon the chemist, for the juice of the roots is chemically distilled and not mechanically expressed. The most striking fact concerning sugar is its increased consumption. In France—for example, in 1840—the consumption was about 6 lb. per annum per head of the population; by 1870 this was doubled, and by 1900 trebled, while at present the consumption exceeds 40 lb. per head annually. Home production of beet sugar accounted for

these totals in 1840 by merely a quarter, in 1870 by three-quarters, and since 1870, except during the period of the Great War, France has generally produced as much sugar as was consumed in the country. This equality, however, did not mean that in France all the sugar used is beet sugar, for there is an export of about a quarter of the beet product in exchange for an equivalent in cane sugar.

So great an increase in consumption has been met by a development in production. At the beginning of this century it is estimated that the supplies of sugar, almost equally beet and



cane, amounted to about 12 million tons, which was ten times the yield in 1840. Of the beet sugar, France, Austria-Hungary, and Russia produced almost equal quantities, while Germany obtained about twice the yield of one of the three. India produced more than half of the cane sugar. Half this output of sugar entered into the world's trade; Britain and the United States each imported about a sixth of the total supplies.

Growth in Sugar Production. Since 1900 the production of beet sugar has been doubled and that of cane sugar quadrupled. While the output in Germany proper and France has but slightly increased, Russia and Austria have doubled their yield, and new producers are important. Poland, Bohemia-Moravia and the United States now each manufacture at least as much beet sugar as France produced in 1900. Similarly, in the case of cane

sugar, India and Mauritius have increased their yield but slightly, while Cuba has advanced to the chief place. This island has more than quadrupled its crop of sugar canes, and a similar advance has taken place in Java, where the total yield now almost equals that of India. Formosa, Puerto Rico, Hawaii, and the Philippines now each produce as much sugar from the cane as Poland produces from the beet. Some of the changes are directly attributable to the needs of the United States. Thus the growth of production of cane sugar in Cuba, Hawaii and the Philippines is connected with an extraordinary development in the United States themselves; while the States have persisted in a mediocre crop of canes, during the last thirty years the yield of beet sugar has grown from practically nothing to an equality with Austria.

Statistics of Sugar Consumption. In Australia, chiefly in Queensland, the yield of cane sugar has been quadrupled during the century, and in the Union of South Africa the yield has grown from tiny amounts in 1900 to an equality with the yield of Argentina in 1930. At present the United States tends to dominate increasingly the world's sugar markets; the total consumption in the States exceeds that of Europe, and is 3½ times as great as that of Britain and 5 times that of Germany, the two nearest competitors. The consumption per head of the population in the States is about 100 lb. annually, whereas that in Britain is but 70 lb. and in Germany only 35 lb. per annum per head. Except in Denmark, where sugar is consumed at the British rate, the rest of western Europe—France, Holland, etc.—consumes sugar at the German rate.

This increased consumption is a reflex of modern tendencies. The eating of sweetmeats—candy in the States, chocolate and boiled sweets in Europe; the larger uses of sweetened tea and coffee as beverages, the growing production of jams and marmalade, the notable developments in the preservation of fruits in cans and bottles—these are all factors of contributory importance. Golden syrup, black treacle, molasses and rum are subsidiary by-products of sugar. On a very minor scale, sugar is obtained from palms and from the maple.

The presence of what are really innocuous impurities left in the manufacturing processes is responsible for the differences in colour and flavour which distinguish certain varieties. Beet sugar refiners, for example, by the deliberate addition of colouring materials to the pure white beet sugar normally produced, seek

to imitate Demerara, the favourite cane product. The sugar-loaf, a glittering crystalline cone, commonly wrapped in blue paper, and once a grocer's exhibit, has almost disappeared from common ken ; its peculiar shape, due originally to the shape of the earthenware vessels in which, under primitive conditions, the juice was set to cool and crystallize, is retained in mind by the titles given to volcanic cores which exist as mountains, notably in the harbour of Rio de Janeiro and in county Wicklow in Ireland.

Historically, the sugar industry has been associated with many changes. It was responsible for much of the prosperity of the British West Indies, with the consequent development of British shipping in the Atlantic Ocean, and the importance of Bristol, Liverpool and Glasgow as seaports. The beet sugar industry owes its rise and original stimulus to the Napoleonic and other European wars of the early nineteenth century. American desire for candy has its reflex in the colonial policy of the United States, which has been directed to the acquisition and control of those sources of necessary raw materials which lay in acquirable lands, chiefly in islands relatively close to American shores.

LESSON 11

Fruit: Its Growth and Distribution

In Britain we are familiar with the produce of our own orchards and market gardens, with our soft bush and ground fruits, and with the tree fruits, such as the apple. Kentish strawberries, Pershore plums, Devon apples, are characteristic. Apples, pears, cherries, nuts such as Kent cobs, red and black currants, gooseberries, strawberries and the like find their way to the shop and the table in season

By reason of our overseas trade and our shipping we are, in all probability, the greatest importers of fruit in the world. In earlier days we turned to the Mediterranean for supplies. and the Christmas trade of a generation ago brought to the shops oranges, lemons, figs, prunes, raisins, sultanas, and currants This trade meant the use of various devices to preserve the fruit in condition for the journey, and the system of drying fruit enabled us to have dates, figs, raisins, etc. We were not able nor did we then feel the need, to inquire closely into the hygienic conditions

which were present, or lacking, when the fruit was being prepared for its journey.

Apple cultivation spread to North America and elsewhere, with the result that American and Canadian apples arrived in our markets As the cultivation of the orange spread—tangerines, mandarins, seedless and Jaffas are commercial types—we obtained supplies from many sources, though we still relied upon Sicily for lemons. Soft fruits, such as peaches and apricots, were at first rare, but the canning industry soon enabled American fruit of this character to be extensively marketed. Pineapples from the tropics came also in tins. Once they were packed whole; now they are sliced, or cubed, or chunked, in order to sell less than a whole fruit at a time.

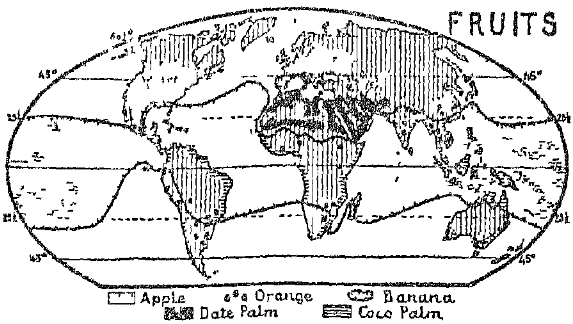
Then came the banana industry. At first a seasonal trade was developed from near-by sources, such as the Canaries; later the traffic was organized, with substantial results to the growers in the West Indies and Central America, and definite transport provision in the holds of ships, as well as systematic handling and storing equipment at the British ports of arrival, all of which is symbolized in the trade label " Fyffe."

With all this growth of traffic, however, in the northern hemisphere we suffered during the off seasons from short supplies, and the consequence was that growers in the southern hemisphere have steadily increased their exports, both in quantity and variety. Tasmanian apples, Australian dried fruits, South African oranges and plums arrive to fill the gap. Tastes change or are developed—witness the rise in the consumption of the tomato, and in more recent times, of grape fruit; witness, by contrast, the failure of the pomegranate. Desiccation was tried: apples, pears apricots, etc., were deprived of water content and sent overseas, for use by the cook in time of scarcity.

Canning and Bottling. Canning in juice grows steadily, and the British grower is now finding opportunity to utilize the extra crops of stone fruit which happen spasmodically, as well as a chance to secure a steady market at a remunerative price; his produce can be held over to the off season. Bottling selected fruits was practised, but the canning industry uses fruit of less expensive quality. The manufacturer also uses fruit extensively in the production of jams, jellies, marmalades, fruit juices, etc. The production of ketchups, etc., is an allied industry.

All sorts of devices are tried for the purpose of carrying the fruit over long distances to the consumer Most of these devices involve machinery, with the inevitable result that hygienic conditions receive attention and the label "untouched by hand" becomes a useful testimonial

Geography of the Fruit Industry Geographically, the fruit trade instances the modern tendency to destroy or nullify the geographical controls Choice fruits from different climates compete in British markets, seasonal effects have disappeared, and distance is almost set at naught The apple grower of East Anglia depends for his prices in part upon the crop which



America produces, the West Indian banana plantation depends for its prosperity upon the maintenance of an effective demand in Britain for the fruit, a maintenance which depends upon extensive advertisement

The following summary is to be taken as merely indicative of the chief tendencies and circumstances obtaining in the fruit industry

Apple temperate trees. Worcestershire, Herefordshire, Devon, Nova Scotia Tasmania

Apricot stone fruit temperate trees France: candied, dried pulped canned kernel used for its oil

Banana tropical sub tropical herbaceous sometimes 25 ft. high West Indies, Canaries

Cherry temperate trees. Germany, dessert fruit, liqueurs; oil from kernels

Cider : fermented apple juice : Brittany ; Devonshire ; Hereford.

Citron . fruit yields thick peel, candied in Italy : citron oil ; citric acid.

Coconut · tropical coast palm, the tree of the coral islets ; fruit gathered four times a year : yields copra and coco-butter ; fibres yield coir.

Currant : English bush soft fruit, source of jellies ; or Greek dried seedless grape.

Date : Mediterranean palm : Tafilet and Saharan oases.

Fig : Mediterranean trees : Izmir (Smyrna)

Grape fruit (shaddock, pomelo) : citrous trees, Mediterranean type : Florida, southern Europe ; supposed by some to be a variety of the orange.

Lemon . Mediterranean trees : Sicily : fresh fruit, juice, oil from the peel.

Lime Mediterranean trees ; also West Indies (Montserrat) : fresh fruit, juice, candied peel.

Mango : Indian trees , chutney ; delicious fruits which have not yet become common in tins or bottles.

Melon : Eastern fruit ; a variety, the water melon, is cultivated, especially in U.S.A.

Olive : Mediterranean trees : Spain, S. France : fruit exported when preserved in brine. (The " palm-olive tree " is a curious fabrication which has attained some currency.)

Orange : Mediterranean tree which has almost lost its localization by expert cultivation : Spain, California, S. Africa, Brazil : mandarins, tangerines, etc. , most useful of the citrons.

Palm oil . West African palm trees ; Nigeria ; oil expressed from the fruit, both pulp and kernels.

Peach : stone fruit of Mediterranean trees : exotic in England ; much cultivated in U.S.A. · enormous trade in tins from California. Variety : nectarines. Union of S. Africa.

Pear . temperate trees : France ; England : " Bartlett " pears canned, a U.S.A. product : " perry," a beverage.

Pineapple tropical American ground fruit : a canned product : West and East Indies.

Plums : stone fruit, Mediterranean trees : fresh or bottled : varieties—greengages, damsons, yellow : dried as prunes or prunelloes cultivation extends northwards through Europe from the Mediterranean : jam : France, Rumania, Yugoslavia. Cape plums, etc., from Union of S. Africa.

Raisin : dried grape : Malaga (muscatels), Marseilles.
Sultana : dried seedless grape : *Izmir*
Tomato S. American plant now widely cultivated, annual : Guernsey, Naples, Malta.
Valencia : Turkish variety of dried grape.

LESSON 12

Tea, Coffee and Cocoa

UNTIL comparatively recent times the white residents of the temperate lands concocted their beverages from the products of their own fields, orchards, and vineyards. "Small beer," ale, stout, lager, cider, the produce of the breweries; whisky and other spirits, the produce of the distilleries, wines, cordials, and other spirituous liquors were all to be had, and intemperance and alcoholism were not infrequent. Times have changed. The tropical zones provide the leaves of a shrub, the berries of other plants, and tea, coffee, and cocoa have ousted the varied alcohols from common use. Little is more striking in Britain than the rise into popularity of the tea-shop.

From another point of view the prevalence of the habit of tea-drinking and chocolate-eating is the consequence of the exertions of the British capitalist and investor in using British money to exploit the resources of Britain's tropical dependencies. Business organization applied to tropical plantations, where labour was cheap and plentiful and where Nature was prolific in its returns, provided Britain with tea, and more recently, with cocoa and the sweetmeat chocolate. When the coffee crops in Ceylon were attacked by disease and became in consequence less remunerative, and Brazil achieved its pre-eminence as a grower of coffee, then coffee-drinking in Britain was prevented from *becoming a national British habit because Brazil* was not British. Both tea and cocoa today owe much to the British and American belief in advertising

Tea, coffee and cocoa, all three, provide a mild and pleasant stimulant, which is, in the main, due to the same chemical elements. Their plant sources all require warm, if not hot, summers with frequent rains during the growing period; the

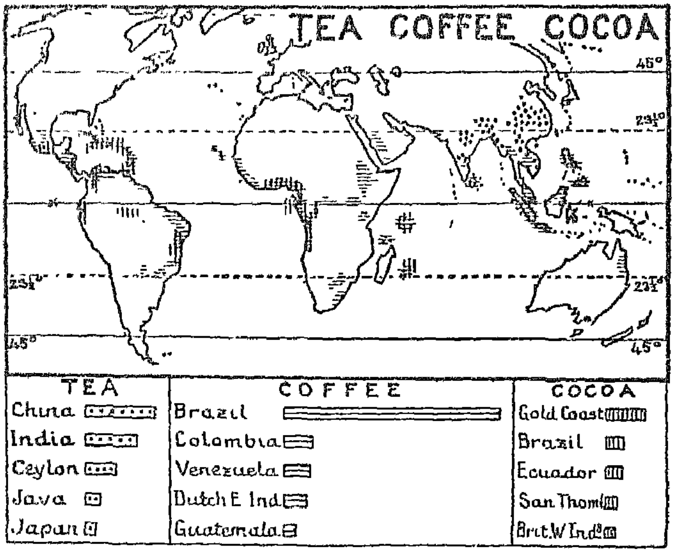
plants themselves are not annuals, like the cereals, and so prices and production are not subject to the violent fluctuations due to seasonal deficiencies or gluts. In the long run, the prevalence of relatively good prices and a steady or increasing demand tend to excessive planting, with the ultimate result that supplies are in excess, prices tend to fall, and control of these industries tends to pass from the industry itself to the transport organizations. Freights tend to bear a high proportion to the wholesale price at which the commodity is marketed, because the labour wages of production tend to be relatively small, for the plantations are worked, in general, on the cheapest forms of hand labour. It is true that modern conditions have created such demands for this low-grade toil that recruitment of workers for the plantations has been organized; yet the supply of extra workers in the almost immediate neighbourhood of the plantations has been adequate, and labour expenses do not tend to increase unduly.

Tea Production. The tea plant is hardy; severe frost merely diminishes the yield. It requires a rich soil, copious regular rains during the growing period, and good drainage, so that the soil is not waterlogged; hill-slopes are suitable, especially if the soil is virgin forest humus. The crop is not reaped *en bloc;* each plant is picked over for the suitable leaves several times. The leaves are put into specially constructed lofts to wither. The next process is rolling, after which the leaves are fermented in a room at a temperature of about 80°F. When this is completed they are "fired" to extract moisture and to prevent further fermentation. Teas differ in flavour, and the favour shown in Britain to dark-coloured Indian tea in preference to the lighter China tea is probably a second consequence of the fact that India is British and China is not. Tea can be grown in other suitable areas than India, Ceylon, China, and Japan; large-scale production elsewhere is hampered by lack of cheap labour and marketing and advertising organization.

The world's production of tea comes from China (40%), India (20%) and the Dutch East Indies, Ceylon, Japan and Formosa, of roughly equal rank. The world's consumption of tea in the countries of large population is, roughly, Britain (40%), Russia (20%), the U.S.A. (10%). Per head of the population both Britain and Australasia consume about 8 lb. annually, Canada about 4 lb., Holland 2 lb., the U.S.A. and Russia 1 lb.

each. Three-fifths of the tea is produced in the British Empire, and about half of it is consumed in the British Empire, chiefly in Britain. Tea is a British beverage. The main producing areas are in north-east India, near Darjeeling; in Assam, along the river Brahmaputra; in central Ceylon, and in eastern China, south of the Yangtze.

Coffee and Cocoa. Coffee is produced from plant seeds, the so-called beans. The plant requires similar conditions to the tea shrub, except that it needs shade and is unable to withstand



frost. The coffee berries are stripped of their outer pulpy covering mechanically; they are then cured by sun-drying in a dry atmosphere. They are subsequently peeled, winnowed, graded, and sorted. For final use the beans are roasted and then ground. Always, dampness tends to loss of quality. Coffee, rather than tea, is the beverage on the continent of Europe. Holland, with its peculiar interests in the development of its tropical possessions—Java, Sumatra, etc.—consumes most coffee per head of the population—a further instance of the circumstance that these beverages are popular because Europe exploited the tropical lands. The best coffee is said to be Mocha coffee,

which has never become popular, for Arabia is a sort of no man's land, and the best of its supply goes to Turkey and Egypt, where coffee is one of the prime luxuries of life.

Cocoa, or cacao, comes from a tropical tree which begins to bear after twelve years. Cacao beans are the seeds, which occur to the number of about forty in a seed pod about eight inches in length; before use for the manufacture of chocolate or cocoa powder a large proportion of the seed, consisting of cacao-butter, a somewhat indigestible vegetable fat, is removed. A naturally disagreeable bitter flavour vanishes during careful fermentation for about a week. The beans are then dried in the sun, later to be roasted and split to form cocoa-nibs. Cocoa was used in Europe before tea or coffee, and for long was a beverage unique to Spain and Portugal, since some of the main sources of the beans were colonies of these countries—a third example of the influence of colonial expansion upon the habits of a mother country.

Brazil is responsible for about three-quarters of the world's coffee, mainly in the São Paulo district back from Santos and Rio de Janeiro. Colombia comes next, followed by Guatemala, Mexico, Haiti, Costa Rica, and Nicaragua. Outside America, India, British East Africa and Java produce smallish quantities. A third of the coffee is consumed in the U.S.A., about 9 % in France, 8% in Germany, and less than 1% in Britain. Per head of the population the U.S.A. use 12 lb.; Holland, Belgium and Scandinavia about the same quantity; France, 8 lb.; Germany, 6 lb.; Britain, less than 1 lb. Coffee is an American beverage.

Roughly, 40% of the world's cocoa is produced in the British Gold Coast; Nigeria and the neighbouring Portuguese islands produce another 10%. Brazil, Ecuador, Venezuela (the original home of the plant and still productive of the finest varieties), and San Domingo produce about 30% between them. Roughly, 40% is consumed in the U.S.A., 15% in Germany, and about 10% in Britain and Holland each, and rather less in France. Per head of the population the largest consumption occurs in Holland, 10 lb.; Switzerland, 5 lb.; U.S.A., 3 lb.; and Britain, France and Germany, each with 2 lb., come next.

Cocoa, once produced in America, is now largely produced in West Africa; its use is mainly as a basis for sweets, especially in U.S.A.

Our Course in Economic Geography is continued in Volume 5.

LESSON 29

Law of Diminishing Productivity

WE observed in Lesson 27 (Volume 3, page 282) that the same laws are applicable to the demand for the factors of production as those which govern the demand for commodities, namely the Law of Price and the Law of Diminishing Utility. In Lesson 28 we dealt with the Law of Price. We saw how the entrepreneur varies the amount which he expends on land, labour and capital, respectively, according to the terms on which they are available to him. Thus, if the price of any one of the factors, say capital, rises, he transfers a part of his expenditure on capital to labour or land. This he is able to do because land, labour, and capital can be substituted for one another at the margin. A manufacturer, for example, who wishes to substitute capital for labour can install labour-saving machinery and dispense with a portion of his staff.

In this Lesson we shall concern ourselves with the Law of Diminishing Productivity, which corresponds to the Law of Diminishing Utility. The Law of Diminishing Utility, it will be remembered, asserts that the utility to us of a given unit of a commodity diminishes with every increase in our stock of it. If you possess five pairs of shoes, an additional pair will have less utility for you than if you possess only one pair. Correspondingly, the Law of Diminishing Productivity asserts that after a certain point the productivity of a given unit of a factor of production decreases with every increase in the supply of that factor. A farmer employing twenty labourers, for example, would find that an additional labourer would increase the produce of his farm by a smaller amount than would be the case if he were employing only fifteen labourers. The farmer would also find that the Law of Diminishing Productivity applies in exactly the same way to land and capital. If he is applying his capital and labour to 100 acres he will find that the hiring of an additional acre would add less to his total produce than would be the case if he were hiring only 75 acres.

In order that we may see how the Law of Diminishing Productivity works out in practice, let us take, as an example, a

farmer who has emigrated to the great wheat belt in North America. In the first year, we will suppose, he works single-handed except for the assistance of his family, and produces a crop of wheat of a certain amount. In the following year he has enough money in hand to hire a labourer, with the assistance of whom he is enabled to treble the amount of his crop, since he can now plough his land with more care, harvest a greater part of his crop before the weather breaks, and perform other tasks which were beyond the capacity of a single man. Thus he finds that the extra sum of money which he obtains from his larger crop exceeds by a large margin the wage he pays to his man. He is, therefore, encouraged to take on a second worker. He can now cultivate his land still more intensively and can harvest his crop still more rapidly. As a result of the cooperation of the second worker, his crop may possibly be increased by a greater amount than was the case when the first worker was taken on. That is to say, although he has only doubled his staff, he may have increased his crop threefold. He might even find that by doubling his staff again in the following season his crop was again more than doubled, since the division of labour and the improved organization made possible by the new increase in staff might quite well be responsible for such an increase in its productivity.

Clearly, however, a point must be reached when his produce will increase by a smaller proportion than the increase in his labour force. Thus he may find that, when he has raised his staff to ten, the Law of Diminishing Productivity begins to assert itself. That is to say, if at this point he increases his staff by $\frac{1}{10}$, i.e. by one man, his produce will increase by less than $\frac{1}{10}$, and so on. If we ask why this is so, we can only answer that it seems to be a law of Nature, which we can discover by quite superficial observation. It is a law which is almost as self-evident as the Law of Diminishing Utility. Let us suppose for a moment that it did not operate. Then if, in the example we have taken, the farmer found that he could go on increasing his staff indefinitely without diminishing the productivity of each additional labourer, it would be possible to raise the wheat supply of the world from this single farm and, as there would be an enormous saving in rent, it would be profitable to do so.

The Law of Diminishing Productivity, however, does not apply merely to agriculture. It is operative throughout the whole field of production. Let us take as an example a cotton mill

with a given quantity of spindles and other equipment. It is obvious that, just as in the case of the farmer, the increase in the output of the mill would in the early stages of hiring operatives increase in greater proportion than the increase in the number of operatives, since, when the staff of the mill was relatively small, each additional operative would facilitate further specialization and improved organization. After a certain point, however, the output of the mill would increase by a smaller proportion than the increase in the number of operatives.

We are now in a position to formulate the Law of Diminishing Productivity in more accurate terms. If successive doses of one factor (land, labour or capital) are applied to a fixed quantity of the other factors, productivity after a certain point will increase in less proportion than the increase in the factor. That is to say, if after a certain point you double the amount of labour employed in any business (the equipment of the business remaining unchanged), you will not double the output. Stated in this way, the Law of Diminishing Productivity is self-evident. "If you double the pastry," says P. H. Wicksteed, "without doubling the apples, you do not double the pie . . . In like manner if you double the land without doubling the operations on it, you cannot expect to double the crop . . ."

LESSON 30

Marginal Theory and the Factors of Production

In Lesson 27 (Volume 3, page 282) it was pointed out that the demand for the factors of production is determined by principles that are strictly analogous to those underlying the demand for commodities, namely, the Law of Price and the Law of Diminishing Utility. Now, as we have seen, the price of any commodity tends to equal its marginal utility, since each consumer, in endeavouring to maximize the satisfaction he obtains from the expenditure of his income, demands just that amount of each commodity which will cause its marginal utility to him to coincide with its price.

Similarly, the entrepreneur, who may be regarded as the consumer of the services of the factors of production, adjusts

the expenditure of his resources in such a way as to bring the marginal productivity of land, labour, and capital into coincidence with their respective prices. For the entrepreneur, like the consumer, is constantly endeavouring to obtain the maximum return from his expenditure. Thus rent, wages and interest tend to equal the marginal productivity of land, labour and capital respectively.

Marginal Productivity of Labour. Let us observe the process by which the earnings of the factors of production are equated to their respective productivities by returning to our example of the farmer, which served in the preceding Lesson to illustrate the Law of Diminishing Productivity. The hiring of the first labourer by the farmer resulted, it will be remembered, in an increase of the produce of the farm by an amount much greater than the labourer's wage. And, similarly, with the second, third and fourth labourers. A point is reached, however, after which the advantages—such as division of labour and the better organization—which are derived from increasing the labour on the farm begin to be offset by the disadvantages of cultivating the land more intensively. That is to say, after a certain number of labourers have been taken on, the hiring of an extra labourer would increase the produce by a smaller proportion than the increase in the number of labourers; and this diminishing productivity continues progressively.

The problem is to ascertain the exact point at which it will no longer pay the farmer to hire an additional worker. Clearly, it will no longer pay him to add to his staff when the hiring of an additional labourer would not increase the produce by an amount sufficient to pay his wage. Let us suppose that the farmer takes on a tenth worker, as a result of which his crop is increased by 100 bushels. If the price he gets for the extra 100 bushels is less than the wage he has to pay, then it will not be profitable to him to retain the tenth worker. On the other hand, if the price he gets for the extra 100 bushels exceeds the wage he has to pay, then he will retain the tenth worker, and possibly take on an eleventh. Thus, so long as the value of the product of an additional worker exceeds the wage he has to pay, it will be profitable to the farmer to increase his staff. The conclusion is that, if he is to maximize his profits, he must hire labour up to the point at which the productivity of the marginal labourer is just equal to the wage he has to pay.

Marginal Productivity of Capital. So far we have worked out the productivity theory of distribution in its bearing upon labour. But the same principles determine the share of the other two factors, land and capital In hiring land or capital, the farmer or entrepreneur will find that, after a certain point has been reached, the productivity of these factors will diminish For example, when the farmer has equipped himself with the more essential farm buildings, implements, etc , he may well find that the investment of a further £100 on equipment for his farm will yield, as in the case of labour, a less than proportional return This diminution in the productivity of the capital he borrows will continue progressively. A point must be reached, therefore, when it no longer pays him to borrow or hire additional capital at the current rate of interest. Clearly this point will be reached when the increase in output, due to the marginal £100 which he adds to his equipment, is just equal to its cost—i.e to the rate of interest he has to pay for it.

As exactly the same argument applies to the hiring of land, we are in a position to make an important generalization about the value of the factors of production In any given economic situation the value (i e. the price) of each factor of production tends to equal the separate contribution of that factor. It is necessary, however, to be careful to interpret this generalization correctly. At first sight it may seem to imply that land, labour and capital share in the total product of the community according to their deserts , that the wages of labour, for example, depend entirely on the efficiency of the worker. This possible misunderstanding is removed if we bear in mind the qualifying phrase with which the generalization begins, namely " in any given economic situation." Thus, when we say that a particular factor of production, say labour, tends to earn an amount equal to its productivity, we are taking for granted the material equipment of the community, the efficiency of the industrial organization and all the other factors in the economic environment. Thus, it is correct to say that the efficiency of labour determines the general level of wages only if we add the proviso " other things being equal." The implications of this proviso will be examined in the Lessons on Labour.

factor tends to find that position in the industrial organization in which its effectiveness is at a maximum ; that is to say, the position in which its contribution to the social income is maximized. This is due to the endeavour of each entrepreneur to distribute his resources in the most economical manner. The consumer, as we have seen, endeavours to spend just so much on each commodity as will maximize the satisfaction he obtains from his income ; so the entrepreneur endeavours to expend just so much on land, labour and capital respectively as will maximize the return from his total outlay.

Nor does the analogy stop there. The entrepreneur has a criterion of the success of his efforts which is strictly analogous to that of the consumer. The consumer, as we have seen, derives the maximum satisfaction from his income when he has brought the marginal utility of each commodity to him into coincidence with its price. That is to say, he adjusts his expenditure so that over a substantial period, say a year, the marginal shilling which he spends on each commodity (i.e. the shilling which he is only just induced to spend) yields him equal satisfaction. For, if the marginal shilling in any one line of expenditure—say, cigarettes—yielded him a greater satisfaction than the marginal shilling spent on beer, then he could increase his total satisfaction by spending less on beer and more on tobacco.

Has the entrepreneur an analogous criterion as to the expenditure of his resources to the best advantage ? Clearly, in order to maximize the profit from his expenditure on land, labour and capital, he must distribute his resources in such a way that the marginal pound he devotes to each factor yields him an equal return. If the marginal pound, the pound which he is only just induced to expend on machinery, yields him a lower return than the marginal pound which he expends on labour, then he can increase the aggregate return from his resources by transferring part of his resources from the hiring of capital to the hiring of extra labour. Thus the entrepreneur is constantly endeavouring to adjust his expenditure on the factors of production so that the marginal productivity of each factor is equal to its price. And, in so far as he is successful, he maximizes not only his own profit, but also the earnings of the factors, as well as their contribution to the social income.

LESSON 31

Rent as a Problem in Economics

IN the three previous Lessons in Economics we have analysed the problem of distribution, and seen that the remuneration of each factor of production tends to equal its specific contribution to the product of industry. We now proceed to analyse the factors of production separately.

Let us be quite clear about the meaning of our terms. What is meant by land and what by rent, the payment made for the hire of land? When we talk of agricultural land, we have in mind fields of corn and vegetables, meadows and orchards. Now, this agricultural land is not land in the strict sense at all, but a combination of land and capital The fields of corn have been cultivated and fertilized, the meadows have been drained, and the land has, in various other ways, been improved by the expenditure of capital A landowner, therefore, will expect from his tenants not merely remuneration for the land itself, but also for the capital he has sunk in the land It is customary to speak of the whole payment which the farmer makes to his landlord as rent, but, strictly speaking, it is partly rent (the payment for the land without improvement) and partly interest (the payment for the improvements) We may define land, therefore, in the terms of the classical economist, David Ricardo (1772-1823), as the inherent and indestructible powers of the soil Thus rent, in the strict sense, is the payment made for the use of the inherent and indestructible powers of the soil.

The problem of rent presents two main questions. Why is the average level of rent what it is? And why is the rent of some pieces of land higher than the rent of other pieces? The former question is concerned with the scarcity aspect of land; the latter question, with the differential aspect.

Scarcity Aspect of Land. To simplify our analysis of the scarcity aspect of land and to place it in its true perspective as the fundamental aspect, we shall assume that the quality of all land is precisely the same This simplifying assumption having been made, the first question that presents itself is: Why does

the farmer not get his land for nothing? Land, being a free gift of Nature, has not cost anything to produce. The answer, of course, is that land is scarce.

There are certain stages in the development of communities in which land is not scarce, and in which, consequently, the problem of rent has not emerged. In order to understand the causes which determine the scarcity of land, let us suppose that a party of colonists settles on an uninhabited island of uniform fertility, and let us observe how land comes to command a rent. In the first stage of colonization each man will have all the land he requires; there is enough for all and to spare. He will, therefore, cultivate that amount of land which will yield the maximum return to his labour and capital. Land being free, there will be no incentive to economize in its use. As the population increases, however, more and more men will settle on the land, until a stage is reached when the amount of land available is no longer sufficient to satisfy the requirements of all. The cultivators will then begin to compete for the fixed supply of available land.

For the purposes of our argument, let us suppose that the land of our imagined island is free and unappropriated. Now, so long as the number of applicants for the available plots does not exceed the number of plots available—twenty of each let us say—the plot holders will make no payment for their land. But let us suppose that the number of applicants grows to twenty-one. Then the twenty-first applicant will be obliged to offer some consideration—some payment—for a plot or part of a plot. The payment he makes will constitute rent. By means of such payments the demand for land will be equated with the available supply.

This emergence of the factor of rent will have important reactions on the methods of cultivation. Farmers, now that they have to pay for the use of their land, will find it profitable to economize in their use of it; that is to say, they will now cultivate it more intensively. More capital and labour will be applied to the cultivation of each acre than formerly. Thus, the farmer will find himself confronted with a new problem, the problem, namely, of how much more intensively he shall cultivate his land. Let us take an arithmetical illustration. The return to successive applications of capital and labour to land must, as we have seen, diminish according to the Law of Diminishing Productivity.

Suppose, then, that the first £100 of capital and labour yields a produce of 1,000 quarters of wheat, the second £100 yields 800 quarters, and the third £100 yields 500 quarters. As long as the land was free, no farmer would expend more than £100 on each acre of his land; for, if he were to expend a second £100 on any acre of land, he would obtain a smaller return than he would do if he took into cultivation an additional acre of land, since, in our illustration, the application of a second £100 on any particular acre would yield only 800 quarters, while the application of this £100 to an additional acre of land would yield 1,000 quarters.

How will the emergence of rent, as a result of the growth of population on the island, affect the situation? Let us now suppose that the increasing competition for land raises rent to the equivalent of 250 quarters of wheat per acre. It will now pay the farmer to apply a second £100 of capital and labour to each acre. For, by applying £200 to one acre, he will get a return of 1,800 quarters (i.e. 1,000 quarters and 800 quarters) minus 250 quarters for rent, that is, 1,550 quarters. On the other hand, if he were to spread the £200 of capital and labour over two acres, as he did before he had to pay rent, his return would be 2,000 quarters, minus 500 quarters for rent.

It is necessary, therefore, to distinguish between the gross and the net return from land. The emergence of rent does not affect the gross return to capital and labour expended on the land, since the farmer will still get 1,000 quarters of wheat from the first £100 that he devotes to each acre. It is the net return to capital and labour that is affected, for he now has to pay 250 quarters for the use of every acre. It pays him, therefore, to economize in the use of land by applying his capital and labour to a smaller area of land. The extent to which he will find it profitable to increase the intensiveness of his cultivation will depend on the amount he has to pay for the land, that is, on its relative scarcity. Thus, in England, where land is relatively scarce and commands a high rent, farmers cultivate their land much more intensively than in Australia, and the gross yield of an acre of wheat land is about double that in Australia.

This is a manifestation of the Law of Price. The English farmer, having to pay more for his land than the Australian farmer, demands less land and, relatively, more capital and labour. On the other hand, the Australian farmer demands more land and, relatively, less capital and labour.

LESSON 32

Malthus and the Population Problem

IN the preceding Lesson we saw that with the economic development of any particular country population grows and land becomes increasingly scarce. More and more food is required to feed the growing population, while the development of the towns encroaches on the available agricultural land. Hence, there is an ever-increasing incentive to economize land. In agriculture farming will be ever more intensive, and in the towns the buildings will tend to become higher. Now, this concentrated use of land will mean that, other things being equal, the return which it makes in response to human effort will decline and the community will become impoverished. For, as we have seen, the "Law of Diminishing Productivity" informs us that an increasingly smaller return will be obtained from the application to land of additional units of capital and labour. Hence, if other things remain the same—that is to say, if there are no new inventions, if there is no improvement in economic organization, if the supply of capital does not become relatively more abundant —then an increase of population must reduce the standard of life. This is the first of the two main aspects of the population problem, namely, the influence the size of the population exerts upon the productivity of human effort. The other aspect of the population problem is concerned with the causes which determine the size of the population

The population controversy, in its modern form, begins with the publication in 1798 of Malthus's "Essay on Population." In this book Malthus was concerned to point out not only that the population problem would wreck an equalitarian society, but that this problem is an ever-present one, that is to say, Malthus maintained that population is ever pressing on the means of subsistence, and always has done so. For potentially, he argued, population is capable of an increase in geometrical ratio, and would, in fact, increase at this rate, were it not for the existence of checks, which are either positive, such as starvation, disease, and so forth, or preventive, such as birth control or abstinence. "Through the animal and vegetable kingdoms," he wrote,

"Nature has scattered the seeds of life abroad with a liberal hand, but has been comparatively sparing in the room and nourishment necessary to rear them."

Population Problem in the 19th Century. The writings of Malthus on the population problem exerted an enormous influence in the first half of the nineteenth century. Not only did he convince the greater part of the influential people of that time that the problem of population hovered threateningly on the horizon, but also that population actually was pressing on the means of subsistence. Nor was he without substantial evidence to support his gloomy conclusion. Population was growing at a prodigious rate and, indeed, continued to do so throughout the 19th century. In the period 1801 to 1901 the population of England and Wales increased from under nine millions in 1801 to 32·5 millions in 1901. On the other hand, food supplies, at the time when Malthus was writing, were failing to increase in like proportion. The stable diet of the masses, bread, rose alarmingly in price. Wheat, which was 34s. 7d. per quarter in the decade 1771–1780, rose to 83s. 11d. in the decade 1801–1810, and to 87s. 6d. between 1811 and 1820.

Towards the middle of the century, however, the gloomy forebodings of Malthus faded more and more into the background. The effects of the Napoleonic wars had spent themselves, and the era of Victorian prosperity had begun. With the development of the railway and the steamship, first wheat and then meat and other foodstuffs poured into this country from the newly developed continents in greater and greater quantities, and at lower and lower prices. Indeed, so great was the influx of food that the agricultural industry at home suffered serious depression.

The first note to disturb this era of Victorian confidence was sounded by Sir William Crookes in his celebrated address at the annual meeting of the British Association in 1898. "All civilized nations," said Sir William, "stand in deadly peril of not having enough to eat. As mouths multiply, food resources dwindle. Land is a limited quantity, and the land that will grow wheat is absolutely dependent on difficult and capricious natural phenomena. I am constrained to show that our wheat-producing soil is totally unequal to the strain put upon it."

Thus the Malthusian devil was unleashed once more with a vengeance. During the decade before the War the view taken by Sir William Crookes became more and more prevalent in

authoritative circles. For population was still increasing rapidly in all parts of the world the great continents of America, Australia and Canada, which were rapidly filling up, were requiring a greater and greater proportion of their food production on which this country was very largely dependent, while the great source of artificial fertilization the nitrate beds of Chile, was inevitably doomed to ultimate exhaustion

It was not, however, until we began to take stock after the War that the alarm became general. In 1919, Mr. J. M Keynes, in his most widely-read book, "The Economic Consequences of the Peace," viewed our position as follows: "The essential facts of the situation, as I see them, are expressed simply. Europe consists of the densest aggregation of population in the history of the world . . The danger confronting us, therefore, is the rapid depression of the standard of life of the European populations to a point which will mean actual starvation for some . . ." This view was endorsed by Mr. Harold Wright in his standard work on population published in 1923, in which he warned us that we have been living "for 50 years in a fool's paradise."

Thus, during the last century and a half, authoritative opinion on the food problem has swung first one way and then another. Up to the 'forties Malthus had convinced us that population was pressing on our food supplies; but with the rise of Victorian prosperity and the development of the new continents this pessimism passed away, only to reappear once more in the 20th century. And now in the last few years the wheel has once more come full circle

Recent Advances in Agriculture. Since about 1923 a silent revolution in food production has been taking place, with the result that the Malthusian devil is again chained up Four main influences have been at work to effect this revolution. First, the great advances that have been made in agricultural technique; second, the progress in plant genetics; third, the progress in agricultural engineering; fourth, the progress in the production of artificial fertilizers. It is impossible to trace here the effects of this revolution One example must suffice. As the result of these combined influences, millions of acres in Australia, the U.S.A., Canada and New Zealand, which were hitherto regarded as waste, have been taken into cultivation.

LESSON 33

Some Effects of an Increasing Population

THROUGHOUT the greater part of the 19th century the writers on the population problem regarded all increases in population as an economic evil. For, they thought, after a certain point all the fertile land will have been taken into cultivation, inferior land will then be increasingly used, and the land in cultivation more intensively cultivated. That is to say, they regarded the Law of Diminishing Productivity not merely as a static law—a statement of what would take place at any time, if all other circumstances remained the same; they regarded it as a law of dynamic development. From the fact that, if at any time the population were instantaneously increased, the additional wealth it would be able to produce with the aid of the additional workers would not be increased in the same proportion, they inferred that the increase in population that had actually taken place had diminished the effectiveness of Man's efforts. They thought, it is true, that improvements in agriculture and industry had to some extent offset the effect of increasing population, but these improvements had not been, in their view, of sufficient importance to counteract the Law of Diminishing Productivity. They were of opinion, that is to say, that, in actual fact, the capital and labour employed in agriculture were already less productive than they formerly had been.

Mill on Population. Even more enlightened thinkers like J. S. Mill (1806–73) were not free from the errors of the earlier writers. Mill, it is true, did not fall into the gross error of thinking that productivity per head had actually diminished, but he shared the view of his predecessors that increases of population are, in general and after a point, an economic evil. He calmly assumed that the great innovations of the 19th century, the railway, the steamship, the development of power production and electricity, could have taken place without the stimulus of an increasing population; and he seemed unable to realize that these inventions required an increase of population, if they were to be effectively utilized.

Professor Sidgwick was the first writer to place the population problem in its true perspective. He showed quite clearly for the first time that not only does productivity per head not diminish, at least until population has reached a point of very considerable density, but also that this point is continually fluctuating according to the state of industrial technique, the rate of savings and other relevant circumstances. This line of thought was developed by Professor Cannan, who introduced the idea of optimum population—the population which is neither too small nor too large, but just right.

In order that we may follow this line of thought, it is necessary to realize that all changes in the size of the population set up counteracting tendencies. On the one hand, an increase of population necessitates a more intensive cultivation of land already cultivated, and a resort to less and less fertile soils; also, the greater the size of the population, the greater will be the pace at which the more accessible and easily worked mines and oil resources will be exhausted. Both these tendencies make for a reduction in productivity per head, and therefore, in so far as they are not offset by other influences, tend to lower the standard of living.

Population and Specialization. On the other hand, a larger population enables important economies in production to be introduced. In the first place, it facilitates greater specialization. As we have seen in Lesson 3 (Volume 1, page 215), an increase in specialization not only increases the efficiency of the worker, but it also enables the special aptitudes of a region or country to be exploited more fully. For example, the growth of world population has resulted in a great expansion of international trade. The greater volume of international trade has enabled Britain to specialize to a greater and greater extent in shipbuilding and the carrying of goods, as well as in all the other occupations for which she has special aptitudes. This greater specialization of Britain has meant the greater specialization of other countries in the production of food and raw materials, and other products which they have exchanged in ever-increasing quantities for the products of Britain.

Nor has the growth of world population meant merely that we have been able to utilize and train our workers to greater advantage, and to exploit more fully our natural advantages. The greater scale of production has enabled more elaborate

machines and plant to be installed than would otherwise have been profitable. One of the principal factors on which the installation of elaborate and more efficient plant depends is the extent of the market. The greater the extent of the market, the more intensively can machinery be utilized, since its cost can be spread over a greater number of units of output. It would not pay, for example, to purchase a typewriter if one wrote only two or three letters a day, but it might be highly profitable to do so if one had to write, say, twenty letters a day. Or, to take a more important example, great economies can be effected in the transport of oil from the oil wells to the ports by the laying down of pipe lines. This, however, involves a very considerable capital outlay, which will be profitable only if the pipe lines are in continuous use, that is, if the production of oil is on a great scale.

Moreover, an increasing population may well stimulate invention. For, as population grows, a higher and higher premium is placed on discoveries such as the railway, the steamship, electricity and various kinds of machinery required for mass production.

We are now in a position to realize that, as Professor Cannan has said, there is only one real Law of Population. "At any given time," writes Cannan, "the population that can exist on a given extent of land consistent with the attainment of the greatest productiveness of industry possible at the time is definite." That is to say, there is at any time a definite size of the population which is the optimum, in the sense that, if it is attained, then a movement of the population either by way of increase or of diminution would result in a lessening of productivity. This optimum, however, is not fixed once for all, as Mill assumed it to be. "The point at which the returns to industry cease increasing," says Cannan, "and begin to diminish, i.e. the point of maximum productiveness, is constantly being shifted by the progress of knowledge and other circumstances, and the shifting is generally in the direction of increasing the population which is consistent with the maximum productiveness possible at the time."

Recommended for Reading: "Population," by Harold Wright, in the Cambridge Economic Handbooks series; A. M. Carr Saunders' "Population" (Clarendon Press); Harold Cox's "Problem of Population" (Cape).

LESSON 34

Land Values and Economic Progress

In Lesson 31 (page 277) we were concerned with the scarcity aspect of land. We saw how, with the progress of society and the growth of population, the demand for land steadily increases, as the expansion of industry and the increase of numbers involve an ever-increasing demand for food and raw materials. It follows that, so long as society continues to progress, there is a tendency for the price of land to rise. Nor is this tendency counteracted by an increase in supply. If the price of, say, motor-cars were to rise as a result of an increase in demand, the supply would normally increase, thereby causing the price to fall back to somewhere near the former level.

Land, however, stands on a different footing. The supply of it is fixed for all time; however great the increase in the demand for land, the consequent rise in price can never be counteracted by an increase in supply. It is this fact which gives rise to the problem of population.

Is the tendency for the rent of land to rise, as society progresses, *necessary* and *continuous?* At first sight it would seem that it is. For every rise in the standard of living and every increase in the population involves an expansion in the demand for raw materials and food, which can be met only by taking inferior land into cultivation or by applying more intensive methods to the already occupied land. These facts led J. S. Mill to assert that " the ordinary progress of a society which increases in wealth is at all times tending to augment the incomes of landlords; to give them both a greater amount and a greater proportion of the wealth of the community, independently of any trouble or outlay incurred by themselves "

Views of Henry George. The founder of the single tax movement, Henry George, carried this point of view to its logical extreme. Not only did he believe with Mill that the progress of society and the growth of population necessarily augment the income of the landlords; he also maintained that the landlords did not merely get a share, but, in virtue of their monopolistic control of the land, appropriated to themselves the whole of the fruits of progress. Thus, according to this view, the other

elements of society—the workers and the entrepreneurs—have received no share in the vast increase of wealth made possible by the advance in technique and in the organization of society. Wages have remained substantially unchanged, asserted George, and so has the rate of profit, while the rise in the rent of land has absorbed the fruits of progress.

On the basis of this analysis, Henry George, in his famous book "Progress and Poverty," a book written with extraordinary verve and persuasive force, was able to put forward a complete and yet practical solution of the economic problem. By one simple measure the State could at once liberate the enterprise of its workers and ensure the equitable distribution of the wealth which they produced. All that was necessary was to impose a 100 per cent tax on land values, thereby appropriating for the community the whole of the unearned increment of wealth created by the activities of society as a whole. The State would then be in a position to abolish all taxes, and to distribute the balance of the revenue on an equitable basis. Nor would the landlords have the power to evade a land tax, since the supply of land is fixed for all time, it cannot disappear. Lay a heavy tax on the *earnings of labour* and the supply of economic activity will be seriously curtailed, lay a heavy tax on the interest of capital, and savings will diminish but lay a 100 per cent tax on land, and *not one square yard of it will disappear.* So ran the argument.

Effects of Progress on Land Values. J. S. Mill and Henry George, however, both completely overlooked the fact that progress affects the demand for land in different ways. Progress due to an increase in population undoubtedly increases the demand for land and raises rent, moreover, a good deal of the technical progress in industry, by raising the standard of life and increasing the demand for the raw materials necessary to feed the new machines, has the same tendency.

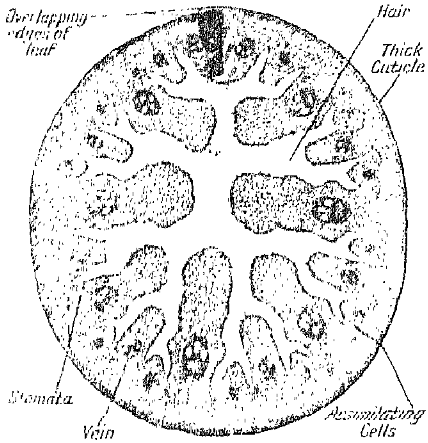
On the other hand, there are important innovations which tend positively to diminish the demand for land. The introduction of new fertilizers—as, for example, Chilean nitrates—while it raises the standard of living, enables economies to be made in the use of land, thereby lessening the demand for it. The opening up of the interiors of Australia and America in the last century by rail transport had a catastrophic effect on agricultural rents in England. In the years 1880–1884 the annual letting value of agricultural land in England fell by 5¾ million pounds. The

great progress since the War in agricultural engineering and technique, plant genetics and artificial fertilizers has also had the effect of substantially lessening the demand for agricultural land.

The fall, however, in the value of agricultural land in Britain during the 19th century has been offset to some extent by a rise in land values in the newly developed countries. The opening up of these countries by railways, and the increased facilities of cultivating them as a result of the improvements in agriculture, have substantially raised the value of their land. The net effect of these improvements, however, has been to lower the value of agricultural land, taking the world as a whole. For any development which enables virgin land to be taken into cultivation is tantamount to an increase in the supply of land. At the beginning of the 19th century the great interiors of Australia and North America were non-existent so far as civilized Man was concerned. Thus improvements in the means of communication, schemes of reclamation, such as that of the Zuider Zee, or progress in agricultural technique, virtually increase the supply of land And by diminishing the scarcity of land they tend to lessen the rent received by landowners.

Values of Urban Land. Even as regards urban land values, the tendency is not all one way. On the one hand, the increase of wealth and the growth of population tend to raise urban land values, since with the growth of industry, commerce and population the size of towns increases. This increase in the size of towns implies an increase in the demand for urban land and, therefore, a tendency for urban land values to rise.

On the other hand, many of the improvements which have occurred in the last century have strongly counteracted this increase in the demand for urban land. Just as certain innovations have enabled Man to economize in the use of agricultural land or to bring new land into cultivation, so means are continually being discovered by which urban land can be economized. For example, the advance of engineering and electricity made possible the underground railways, which have economized land in two ways. In the first place, they have obviated the use of urban land for the railway track; and, in the second, they have cheapened and speeded up transport, thereby enabling housing estates to be developed in hitherto country districts and thus relieving the housing congestion in the towns and cities.

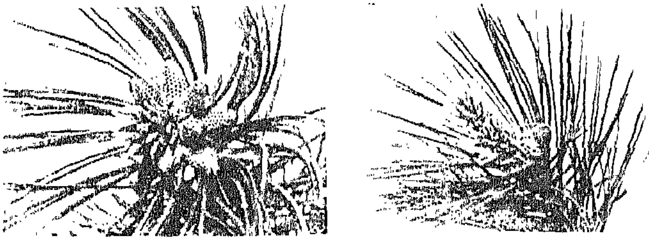


MARRAM GRASS. Photomicrograph of rolled leaf, showing vascular bundles in ground tissue and hair projections. The leaf curls inwards in hot weather to prevent loss of water. BOTANY 26

Photo, H. S. Chearin

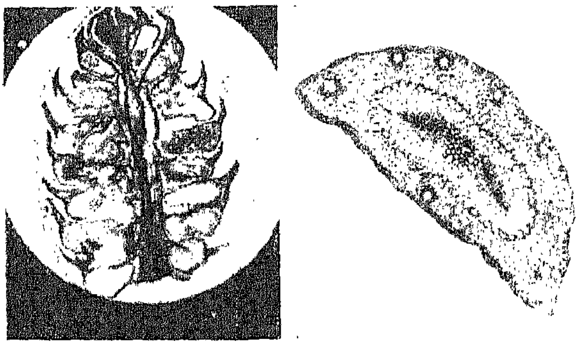
SUCCULENT PLANTS. Special water-storage tissue is most highly developed in desert flora such as cactus plants, two species of which are shown here: left, Opuntia microdasys, or prickly pear; right, waxy flower of a typical cactus plant. BOTANY 26

Photo (right), Reginald A. Malby



SCOTCH FIR (PINUS SYLVESTRIS). Left, cluster of young female cones and young dwarf shoots in centre. Right, young dwarf shoots of male flower and needle leaves of previous year's growth. BOTANY 27

Photos, H. S. Chearin

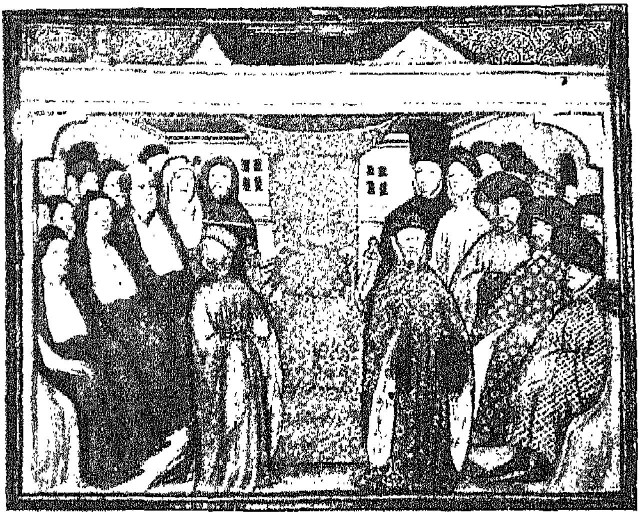


CONE AND LEAF. Left, longitudinal section of male fir-cone. The pollen sacs, which lie beneath the scale-like stamens, are shown both full and empty of pollen. Right, transverse section of leaf; it contains a ring of resin-ducts in the exterior rim. BOTANY 27

Photos, H. S. Chearin

RICHARD III. One of the "villains" of English history, he was born in 1452, and seized the throne from his nephew *Edward V*, in *1483*. *He* was killed at Bosworth in 1485. BRITISH HISTORY 7

HENRY V. Born 1387, he succeeded his father in 1413. He invaded France in 1415 and made large conquests, but died in 1422 before his triumphs had been consoli-*dated.* *BRITISH HISTORY 7*



DEPOSITION OF RICHARD II. Henry of Lancaster returned to England in 1399 ostensibly to recover the patrimony of which he had been deprived, but he obtained such a measure of support that he was able to make a bid for the crown. On September 30 Richard II signed a deed of abdication, whereupon Parliament deposed him and installed Henry—shown here wearing a high cap—on the throne as Henry IV—the first of the Lancastrian kings. BRITISH HISTORY 7

British Museum, Harleian MS.

HENRY VII (1457–1509). Born at Pembroke, after the slaughter of the Wars of the Roses he claimed the throne of England as representing the House of Lancaster, and defeated and killed Richard III at Bosworth in 1485. By his marriage with Elizabeth of York he healed the feud between the rival houses, York and Lancaster.
BRITISH HISTORY 8

SIR THOMAS MORE (1478–1535). Scholar, statesman, and framer of the original "Utopia," he became Lord Chancellor in 1529, but was beheaded six years later because of his refusal to acknowledge the royal supremacy in matters of religion. BRITISH HISTORY 8

HENRY VIII (1491–1547). Succeeding his father in 1509, Henry VIII (shown here, in this painting by Holbein, with his daughter Mary and the royal jester) shook off the Pope's authority and obtained absolute power in Church and State. BRITISH HISTORY 9

LESSON 35

Differential Aspect of Land

In our analysis of the scarcity aspect of land, we made the simplifying assumption that all land is of the same quality. Land, however, like all economic goods, varies enormously in its capacity to serve the purposes of Man. There is, for example, a considerable difference in the utility of an acre of land in the neighbourhood of Piccadilly and an acre of land in the Highlands of Scotland. Now this difference in the quality of land suggests two questions: (a) what determines the difference in value of different pieces of land, and (b) on what principle are the various pieces of land parcelled out for the various purposes, *e.g. agriculture, factory sites, housing, etc.*?

From the barren land near the peaks of the Welsh mountains to the fertile farms and market-gardens within easy distance of London, we can imagine the different pieces of land in Britain to be arranged in order of their quality. Between the two extremes of land which is too barren and too inconveniently situated to have any value at all, and of land which is highly fertile and situated within easy communication of its market, there will be a grade of land which it is only just worth while to cultivate. This grade of land, being on the margin of cultivation, we may call "marginal land"; and it is on this marginal land that we must fix our attention if we are to interpret the differences of value of the various grades of land.

Rent of Marginal Land. First, we have to ask: What will be the rent of this marginal land? How much rent will the farmer who cultivates it be prepared to pay? A moment's reflection will show that he will not be prepared to pay any rent at all. Marginal land, in fact, commands no rent. For, if any appreciable rent were charged for it, it would not pay to cultivate it. The sceptical reader may think that this is all very well in theory, but he would like to meet one of those lucky farmers who get their land for nothing, or one of those benevolent landlords who are so considerate to their tenants.

There is, however, a not inconsiderable number of landlords whose land does not yield them a net rent. In this connexion

it is essential to distinguish the net from the gross rent of land A landlord does not merely let the bare land to the farmer There are the farm buildings and other permanent improvements for which the landlord has had to lay out a capital sum In many cases the rent which the farmer pays just covers the interest on the capital sunk in the farm which he occupies, and the landlord lets the farm in order to secure what is, in effect the payment of interest on his capital Moreover a farm usually contains land of varying quality, some of which is not infrequently marginal land in the sense that it would not be worth occupying if any appreciable rent were charged for it and the farmer, who will pay rent for the land of superior quality, will get the marginal land thrown in for nothing

Thus the marginal land consists of that land the produce of which only just covers the costs of cultivation plus a normal return to the farmer Nothing is left over for rent But what of the land the quality of which is superior to the marginal land? What determines the rent paid for this better quality land? It will be sufficiently obvious that the rent of a piece of land will tend to equal the differential advantage of cultivating the land in question rather than land on the margin of cultivation Suppose a farmer is thinking of renting a particular farm, how will he compute the rent he is prepared to pay? Clearly, he will estimate how much the proceeds of the farm will yield on the one hand, and how much expense he will incur in running the farm plus a normal profit for himself, on the other If there is a balance after he has allowed for his expenses and his remuneration, he will be prepared to offer the amount of this balance as rent He will not offer more than this—otherwise he would not obtain adequate remuneration for himself It is useless for him to offer less, for he would be outbid by the competition of other farmers Thus the landlord is able to obtain for the use of his land a rent amounting to the value of the differential advantage of cultivating his land, in excess of the zero rent obtained from the marginal land

Rival Demands for Land. So far we have considered the demands for land as if they were uniform It is now necessary to distinguish the different kinds of demand for land, since land may be used for a variety of purposes When we take account of the variety of uses to which a piece of land may be put, the conception of the differential advantage which a piece of land possesses over the marginal land becomes more complicated The marginal

land for houses (the land on which it only just pays to build houses) is obviously not the same as the marginal land for agriculture. The marginal land for houses, offices, or cinemas certainly cannot be described as sites which yield no rent.

As regards urban pieces of land, there can be no doubt as to the purposes for which they can most profitably be used. A site in Threadneedle Street can obviously be used more profitably for offices than for any other purpose. But just as there are pieces of agricultural land which it is only just worth while to take into cultivation, so there are pieces of land which it is only just worth while to employ as sites for houses. But these marginal housing pieces of land will not be no-rent land as was the case with the marginal agricultural land. For they will have alternative uses to which they can profitably be put; they can be used for agriculture, for example, or as private gardens. How can we estimate the rent which these marginal housing sites will command? Clearly a rent will have to be paid for marginal housing land sufficiently high to prevent it from being used for agriculture. Similarly there are alternative uses to which agricultural land can be put. The highly fertile hop land of Kent could be used for wheat, vegetables or fruit growing. Hence, the marginal hop land will command a rent sufficiently high to attract it away from its most profitable alternative agricultural use. And the better quality hop land, the hop land that is superior in quality to the marginal hop land, will command a rent higher than that of the marginal hop land, in proportion to the differential advantage of cultivating the superior land in question.

Margin of Transference. Just as we found it necessary, in our analysis of consumers' demand, to focus our attention on the marginal utility of goods and services, and in our analysis of distribution, on the marginal productivity of the factors of production, so, in the case of land, it is at the margin that the significant changes from the social point of view take place.

When agricultural land is taken over for the purpose of housing or when houses are pulled down to build cinemas, changes are taking place which are of considerable importance for the community. If agricultural land is taken over for building sites, the community is affected by the resultant tendency for the prices of farm produce to rise and by the inroads into the countryside. If houses are pulled down to build cinemas, this will mean that house room will become more expensive.

LESSON 36

Saving from the Viewpoint of Economics

We have already seen in the Lessons on the economic organization that the element of time plays a fundamental rôle in production. In the first place, the actual processes of production take time. From the moment when the necessary raw materials of a motor-car, for example, are assembled at the factory to the final stage when the complete car emerges, a considerable period of time elapses. In some cases the process of production is comparatively short; in others, such as agriculture, it is comparatively long; but in all cases production takes time. Nor is the element of time involved only in the actual process of production. It is also involved in the provision of the machines, buildings and other forms of fixed capital. For all these durable means of production take time to wear out. If, for example, a manufacturer decides to install a certain machine, he lays out the money for it immediately he makes the purchase, but several years must elapse before he can extract from it its full utility. To put the point technically, the " consumption " of fixed capital takes time. Thus, if production is to be profitably carried on, the element of time involved in the processes of production and in the use of durable instruments of production, must be provided for.

To take an example: in order that a farmer may bring wheat to market next year, it is necessary that he should prepare the soil and sow the seed this year. It is also necessary that he should harvest the wheat and stack it until it is ready for threshing, before he will be in a position to bring it to market to get the return for his labour and to recoup himself for the expenses he has incurred; that is to say, he has to maintain his workers and himself, and pay for his seed during the year that must elapse before his produce is ready for the market. But in order that he may be in a position to do this, either he or someone else must previously have consumed *less* than their purchasing power entitled them to do. In other words, in order that the farmer may be provided with the necessary capital to tide him over this

intervening time period, either he or someone else must have saved. If the farmer himself has not saved the necessary amount, then he must either borrow it direct or, as happens in *most cases, through the medium of the banks.*

Necessity of Saving. Thus the element of time involved in production is provided for by saving, or " waiting," as economists often prefer to call it As Mr. H. D Henderson puts it in " Supply and Demand " :

" It is not enough that the farmer and his labourers should work; *no less essential* is it that *someone* should wait. The farmer must wait until he has sold his crops, both for the reward of his own labour and for the repayment of the wages he advances in the meantime to his labourers Or, if he cannot afford to wait, and borrows in anticipation of the harvest, then the lender must wait until the farmer, having sold his crop, is able to repay him. Thus the period of time involved in all production gives rise to a demand for waiting which is the essential reality underlying the phenomena of capital and interest. It is really this which constitutes an independent factor of production distinct from labour and nature and equally necessary."

Waiting, however, is not only essential for the provision of circulating capital. The provision of fixed capital is equally dependent on waiting. When, for example, the farmer purchases a new tractor plough, either he or the lender (if he borrows the money) must " wait," until he can recoup himself from the sale of the crops the plough enables him to produce. He has to lay out the necessary purchase money at the time when he requires the tractor, but he has to " wait " several years before he can extract from it its full utility. Or take the case of a man who purchases a house for £1,000. He lays out the money when he requires the house, but many years elapse before it yields him a £1,000 worth of services. During this period he must wait.

A person is said to save when he refrains from spending a part of his income. If a man has an income of £500 a year and he spends only £300, he will save the balance of £200. The savings of the community consist of the sum of the savings of individuals. Thus the annual national savings in any year equal the sum of the differences between the money incomes of individuals and their money expenditure on consumption. The total savings constitute the amount available for investment. Saving, however, is a merely negative act. In order that saving may become

embodied in some form of capital, it is necessary that someone should make use of the money that is saved. In the Lessons on the economic organization we saw how the various institutions which make up the financial system of the country facilitate this process of the translation of savings into capital. Thus the banks are responsible for the provision of the bulk of the circulating capital required by the business world. When a person decides to keep a cash balance of £50 at the bank, he is virtually providing the community with circulating capital, for the bank is enabled thereby to extend its loans to business men.

While the banks are mainly responsible for the supply of circulating capital, the stock exchange, the issuing houses, and "financiers" are responsible for the supply of fixed capital. Thus when a person decides to invest £1,000 in, say, the motor industry, he instructs his stockbroker to make the necessary purchase of shares. This transaction, of course, does not of itself result in an increase of fixed capital its immediate effect is merely to transfer the ownership of a certain amount of share capital from one person to another.

Hoarding of Savings. The rate of investment, however, does not necessarily correspond to the rate of saving. This is notoriously the case during a trade depression, when capital accumulates in the banks. It is this excess of saving over investment which is the proximate cause of the decline in business activity and the increase of unemployment. For the savings which would normally be spent on building factories and ships, on producing machines and the various forms of material equipment, run to waste in the banks. This is because business men are so uncertain about the future that they are unwilling to undertake new enterprises, however abundant and cheap the supply of capital may be.

In normal circumstances, however, the rate of investment keeps in step with the rate of saving. To maintain this harmony between saving and investment is the chief function of the Bank of England, its weapon for this purpose being the bank rate. If investment is tending to run ahead of saving, it can discourage borrowers by raising the bank rate, and vice versa. Thus the bank rate plays the same rôle in relation to the demand for capital as prices play in relation to commodities in general. It cuts off all demand in excess of the available supply.

Our Course in Economics is continued in Volume 5.

LESSON 22

Engineering Aspect of Refrigeration

(See plate 42)

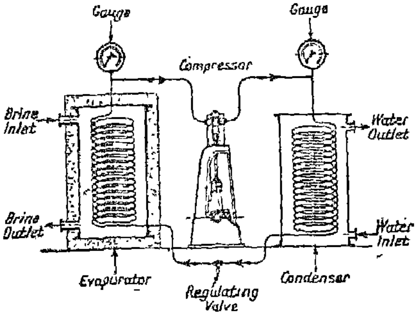
WE have dealt in previous Lessons in this Course with the production of heat and the conversion of heat to work. The mechanical production of cold is a further branch of engineering, with its own special problems and difficulties, and it is a branch which is of increasing importance in our everyday lives: Meat from the Argentine, mutton from New Zealand, fruit from South Africa, etc., are made possible only by the application of refrigeration Our supplies of fresh fish, fresh meat, fresh milk, and of certain classes of fruits and vegetables, depend upon the preservation of these articles at the correct temperature during the period which elapses between their collection from the producers and their distribution to the consumers Refrigerating plants are also used in industrial processes —for example, in the brewing industry—and for the cooling of the air supply to theatres and other large buildings.

In any refrigerator the working substance (called the refrigerant) passes continuously through a cycle of operations. At one part of the cycle, while the refrigerant is at a low temperature, heat is absorbed from the body to be cooled, and at another part of the cycle heat is given out to some cooling medium, usually water or air. In order that the working substance may take in the heat while at a low temperature and give out the heat while at a higher temperature, it is usual for the substance to pass through changes of state during the cycle of operations. At certain stages it is in a liquid form ; at others it is a vapour. In order to understand the operation of a refrigerator it is necessary to be quite clear as to the conditions under which a substance changes from liquid to vapour or from vapour to liquid.

We have already considered, in connexion with steam engines and boilers, the processes of evaporation and condensation, but it would be well to recapitulate briefly the main points. For a given substance the change of state from liquid to vapour takes place at constant temperature, called the saturation temperature. Heat must be supplied to the liquid during evaporation, and abstracted from the vapour during condensation. This heat,

which causes a change of state but no change of temperature, is known as the " latent heat." The saturation temperature depends upon the vapour pressure acting upon the liquid, and upon the nature of the substance itself.

Refrigerative Substances. At atmospheric pressure, water evaporates at 100 degrees Centigrade, but at 200 lb./sq. inch the saturation temperature is raised to 195 deg. C. Two of the substances used extensively in refrigeration are carbon dioxide and ammonia. At atmospheric pressure carbon dioxide evaporates at a temperature of −80 deg. C., that is, it is a gas at ordinary temperatures; in order to raise the saturation temperature to 0 deg. C. it is necessary to increase the pressure to about 500 lb./sq. inch. For ammonia the saturation temperature is −33 deg. C. at atmospheric pressure, 0 deg. C. at about 60 lb./sq. inch, and 20 deg. C. at 125 lb./sq. inch. Thus, if we have liquid carbon dioxide at a pressure lower than 500 lb./sq. inch, or liquid ammonia at a pressure less than 60 lb./sq. inch, contained in a vessel immersed in water the refrigerant would absorb heat from the water and evaporate, since its saturation temperature would be lower than 0 deg. C.



REFRIGERATION. Fig. 1. Simple diagram showing the principle of the refrigerating machine.
Courtesy of Messrs. J. & E. Hall Ltd.

The absorption of heat from the water first reduces its temperature to 0 deg. C., and then, as further heat is extracted at this temperature, the water is gradually converted to ice. If the operation is continued beyond this point, the temperature of the ice is further reduced until it approaches the saturation temperature of the refrigerant.

Nearly all refrigerators are of the " vapour-compression " type. The sequence of operations may be best described with the aid of the diagram shown in Fig. 1. The plant consists essentially of four parts: the compressor, the condenser, the regulating valve and the evaporator. These are connected by piping to form a closed system through which the refrigerant circulates.

The compressor is similar in principle to the reciprocating type of air compressor discussed in Lesson 21 (Volume 3, page 306), and is fitted with automatic suction and delivery valves. The refrigerant enters the compressor cylinder as a vapour at a low pressure and temperature and is compressed to a high pressure, and to the corresponding saturation temperature The high pressure vapour then passes to the condenser in which cooling water flows around the pipe containing the refrigerant, the latter gives up its latent heat to the cooling water, and the vapour condenses to liquid at the same pressure and temperature. Usually, in order to ensure that the vapour is completely condensed, the liquid is further cooled slightly below the saturation temperature. The refrigerant leaves the condenser as a liquid at a comparatively high pressure and moderate temperature.

The regulating valve is simply a restriction to flow along the pipe, resulting in a difference in pressure on the two sides of the valve. The valve is used so that the restriction to flow may be varied to suit different conditions of operation; while the plant is working normally the valve remains fixed in a definite position. The amount of the restriction must be such that, at the reduced pressure after passing the valve, the saturation temperature of the refrigerant is less than the temperature of the substance to be cooled. In the case considered in Fig. 1, the substance to be cooled is brine, a solution of common salt in water, brine is used because it does not freeze at the temperatures used in practice.

Cycle of Refrigeration. The liquid refrigerant at a low pressure flows into the evaporator, where, on account of the difference between the saturation temperature of the liquid and the temperature of the brine, heat flows from the brine and the liquid evaporates, leaving the evaporator as a vapour at a low pressure and a low temperature. It then enters the compressor, where it is compressed again and proceeds to repeat the above cycle of operations. The brine is cooled as it flows through the evaporator, and is then circulated through pipes in the cooling chambers at the rate required to keep these rooms at the required low temperature.

It will be seen that the plant holds two closed systems containing continuously circulating fluids. The brine absorbs heat from the atmosphere in the storage chambers, and gives out this heat in the evaporator. The heat given out by the brine is absorbed by the refrigerant as it evaporates, and this heat,

together with the heat given to the refrigerant in the compressor, must be given up to the cooling water in the condenser. The action goes on continuously, the rate of circulation of the refrigerant being controlled to give the desired conditions of temperature in the cooled chambers.

In some plants, especially in the smaller sizes, the brine is dispensed with, and the evaporation of the refrigerant takes place in the space to be cooled. This would, of course, be unsuitable where one plant is used to cool a large number of chambers, perhaps considerable distances apart. Figs. 2 and 3 (Plate 42) show parts of the plant used to carry out the operations discussed above. The former is a photograph of a three-cylinder compressor for an ammonia plant, driven by a 180 horse-power electric motor. The compressor is single acting and single stage, the three cylinders being used to give a more uniform turning moment on the crankshaft. The other illustration shows an atmospheric condenser, air instead of water being used to condense the refrigerant after it leaves the compressor. The coils of tubes are usually mounted on the roof of the engine-room, or in some convenient position in which there is an ample circulation of air.

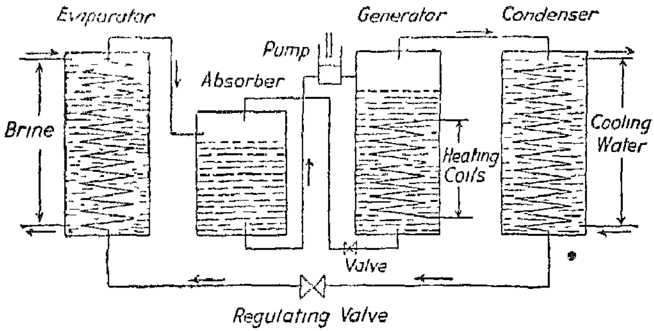
LESSON 23

Refrigerators for Stores and Home

(See plate 43)

In the preceding Lesson the vapour-compression type of refrigerator was described. We must now consider another type of refrigerating plant, the vapour-absorption type. The absorption plant is not so suitable for large sizes as the compression type, because it is not so efficient in operation. For small installations, however, it has decided advantages on account of its simplicity in operation. One well-known household refrigerator operates on a modification of the vapour-absorption cycle; it has no moving parts whatever, and is therefore free from mechanical troubles. It only requires the application of a small gas or oil flame at one part of the apparatus and a small supply of cooling water. It is on account of the possibilities of this type of plant for small refrigerating sets that a description is included in this Course of Lessons.

The refrigerant usually employed in such a type of refrigerator is ammonia, and the name "absorption" is derived from the fact that in one of the operations the ammonia is absorbed by water. The cycle of operations is indicated diagrammatically in Fig. 1. The evaporator, the condenser and the regulating valve serve the same purposes as in the compression type of plant, but the compressor is now replaced by two vessels, the absorber and the generator, and a small pump. In the absorber the low pressure and low temperature vapour leaving the evaporator is absorbed by water, in which ammonia is readily soluble. The solution of ammonia and water is pumped into the



REFRIGERATOR. Fig. 1. Diagram showing the cycle of operations in an absorption type of refrigerator.

generator, where the pressure is high. Heat is applied to the generator, either by a direct flame or by steam heating coils, and the ammonia is released from the water as a high pressure vapour. It is then condensed to a liquid in the condenser, and the liquid ammonia is allowed to flow through the regulating valve to the region of low pressure. The low pressure is such that the saturation temperature at this pressure is less than the brine temperature, so that heat flows from the brine to the ammonia, which evaporates; the vapour passes to the absorber, and the cycle of operations is complete.

It will be seen that the essential difference between the two types of plant is in the arrangements made for raising the pressure of the ammonia vapour. In one case this is done in a compressor; in the other case the vapour is absorbed by a liquid, the liquid is pumped into the high pressure generator, and the vapour is

liberated from the liquid by heating. The water from which the ammonia has been driven off is returned to the absorber by way of the valve shown, so that the same water is used continuously. This latter method would be too cumbersome for large plants, for which the compressor is invariably used In one modification of the absorption type of refrigerator, however, the necessity for the pump is eliminated, so that, as stated above, there are no moving parts whatever; this is a very important consideration when the apparatus is required to work without skilled attention

The modification made to the absorption plant to eliminate the pump lies in the introduction of another gas at one part of the cycle. The high pressure part of the cycle is as described above. The high pressure liquid ammonia leaving the condenser flows to the evaporator, to which a supply of another gas, hydrogen, is also furnished. The total pressure is approximately constant throughout the whole plant. Now, when two gases are mixed, the total pressure is equal to the sum of the pressures that each would exert if it alone occupied the space under consideration

The pressure of the ammonia in the evaporator is, therefore, less than its original pressure by the amount of the pressure of the hydrogen. Further, the saturation temperature of a liquid does not depend upon the total pressure acting upon its surface, but upon the pressure exerted on it by its own vapour. Hence the introduction of the hydrogen reduces the saturation temperature of the ammonia. If this saturation temperature is less than the temperature of the substance to be cooled, heat will flow to the ammonia and it will evaporate. The mixture of ammonia vapour and hydrogen passes to the absorber, where the hydrogen is released as the ammonia is absorbed by the water, the hydrogen then returns to the evaporator, the whole process being continuous.

The important point about the refrigerator just described is that the total pressure is approximately constant throughout, so that there are no valves to be considered; the effect of a low pressure at one part of the cycle is obtained by introducing the other gas. The vessels are charged with the correct quantities of water, ammonia, and hydrogen during manufacture, and the whole apparatus is sealed up. It is only necessary for the user to supply the heat for the generator and a supply of cooling

water The evaporator is usually placed directly in the chamber to be cooled, and the brine is not required.

Cold stores are required for the preservation of perishable food-stuffs of all kinds Ships are fitted with cooled chambers for the transport of meat, fruit, butter, etc., over long distances and through tropical climates. After arrival in this country these supplies must be kept in storage until distributed to retailers, and now even the retailers are finding it advantageous to install refrigerated chambers in which to store their perishable goods Finally, in warm countries refrigerators are installed in individual houses.

In large plants the storage rooms are cooled by the circulation of cold brine through pipes attached to the walls and ceilings, as shown in Fig. 2 (Plate 43) To reduce to the minimum the quantity of heat to be abstracted from the air in the room, the walls are insulated, that is, padded with some material, such as cork, which resists the flow of heat from the outside. The actual conditions required inside the storage room depend upon the particular product to be stored. Much research work is being carried out in order to determine the best temperature for different classes of food, and the periods during which they may be stored without deterioration.

Home Refrigerator. A domestic refrigerator is shown in Fig. 3. The cooling unit in this case is of the type described above, in which all the mechanical parts are eliminated. The evaporator is placed inside the cupboard, behind the ice trays seen on the right-hand side. The other parts are placed in the smaller cupboard partly hidden by the open door One of these cooling units is shown in Fig. 4, detached from the cupboard and mounted upon a stand for demonstration purposes. It will be seen how the evaporator is separated from the other parts of the apparatus, so that the cooling effect may not be reduced by the conduction of heat from those parts which work at a higher temperature. Although, as stated earlier, the absorption refrigerator is not, in general, as efficient as the compression type, the simplicity and compactness of the above type give it a decided advantage when compared with other refrigerators in which a compressor and either an electric motor or some type of engine are essential features.

LESSON 24

Factors in the Use of Water-Power

(See plate 44)

THERE has been great development in recent years in the water-power resources of this and other countries, and this development is likely to be continued in the near future, more especially in those countries which have not got a plentiful supply of either coal or oil. While the generation of power from water is a very attractive proposition, it has the disadvantage that, in general, the most favourable position for the power plant is fixed by Nature, and is usually removed a considerable distance from the best positions for the utilisation of the power. Mountainous districts with heavy rainfall are best suited for water-power schemes, but these are not the best conditions for the location of industrial works. Instead, ease of transport and proximity to supplies of raw materials have been the determining factors in the past.

The great advances made in the distribution of electrical energy have opened up a new field for the application of water-power. Whereas, in the past, the utilisation of the power available from running water was confined to small plants, situated on the side of a stream and using the old-fashioned water-wheel, it is now possible to generate power in large stations, situated in the most convenient positions for efficient operation, and to distribute this power by electrical conductors over large areas to individual consumers. The water-wheel has been superseded by the water turbine, and the efficiency of the power station has been raised by continual improvements to plant and equipment. As more experience is gained with this form of power production, and as more knowledge becomes available as to the natural water-power resources at our disposal, it is to be expected that further development will take place. This development will depend, of course, upon the supplies of coal and oil available as an alternative source of power, but for political as well as economic reasons those countries which have only small supplies of fuels will develop their water resources to the utmost.

The design and construction of a water-power scheme presents many problems of a diverse nature. In connexion with any

proposed scheme it is first necessary to obtain information concerning the rainfall in the area considered and the rate at which this water finds its way into the streams and rivers. This latter question depends largely upon the geological nature of the subsoil, and is very important, as it determines the minimum quantity of water which will be available. From a knowledge of the minimum quantity available and the average flow, it is then possible to determine the amount of storage which will be necessary to generate the required power. The natural facilities for storage, such as lakes and ponds, must be taken into account, as well as the cost involved in providing artificial storage. These conditions of minimum flow and capacity for storage set a limit to the power available.

After a preliminary inspection of the prospects of a particular scheme, a survey must be made in order to determine the best positions for dams, power-houses, etc. Alternative schemes are then prepared, and estimates made of the cost of different types of construction and different arrangements of plant. When the most suitable scheme has been selected the constructional work begins. This involves, on the part of the civil engineer, the building of dams, boring of tunnels, laying of pipe-lines and digging of canals. The mechanical engineer builds and installs the water turbines, valves, control gear, etc., while the electrical engineer is responsible for the erection of the generators, transformers, power transmission lines, sub-stations, and all equipment necessary for power distribution.

In any power scheme the energy available in the water depends upon the quantity of water flowing through the turbine and upon the available "head." The head of water is the height, measured vertically, from the level of the water in the reservoir to the level of the water in the tail race leaving the power-house. If 1 lb. water falls through 20 ft. it is capable of doing 20 ft. lb. of work, so that the energy available in the water is directly proportional to the head, or the distance through which it falls. For a given power, therefore, the quantity of water required depends upon the available head; the lower the head of water, the greater the quantity necessary. Further, the greater the quantity of water to be dealt with, the greater the size of the turbines, power-house, canals, etc., and therefore, the more expensive the whole project. It will be seen from the above that the available head of water is one of the important factors in deciding the most favourable site

for a water-power plant On the other hand, a high head of water is generally associated with a rapidly-falling stream, that is, it is only available in mountainous districts, and, therefore, a considerable distance away from industrial centres. Indeed, in certain cases it has been found more economical to build the plant in a position where only a low head has been available, rather than to convey the power over the long distance from a site where there is a high head of water

Rainfall. In an estimation of the probable quantity of water available from any given district, and the probable fluctuations in the flow of the streams and rivers, it is very helpful to be able to refer to accurate records of the rainfall over long periods. In any district the rainfall varies from month to month and from year to year, and it varies in different districts according to their geographical position and physical configuration. Mountainous districts which are situated in the path of winds that have passed over large stretches of water have generally a heavy rainfall. In the British Isles, for example, the prevailing wind is from the south-west, and this becomes charged with moisture in its passage over the Atlantic. The mountainous districts on the west coasts of Ireland, England and Scotland have, therefore, a heavier rainfall than the more easterly districts. Cork and Kerry in Ireland, Wales, and Cumberland in England, and the Western Highlands in Scotland are the districts with the heaviest rainfall. It will immediately be noticed that, in general, these are not highly industrialised districts, and, therefore, water-power plant erected in these regions cannot rely upon an extensive demand for power in the immediate vicinity.

Stream Flow. The variations in the flow of a stream depend upon many factors besides the quantity of rain falling on the area drained by the particular stream. While a certain amount of the rain flows almost immediately into the streams and rivers, a large quantity sinks into the ground, and only gradually finds its way to the streams. The quantity which sinks into the ground in this way depends upon the nature of the subsoil, whether impervious, as with clay, or porous, as with sandy subsoil. It depends also upon whether the ground is flat or hilly, and upon whether the surface is wet or dry.

The most favourable district for a water-power scheme is that in which only a small proportion of the rain flows immediately into the streams. The water which sinks into the ground acts

as a natural reservoir, maintaining the flow of the stream in times of drought, and reducing the tendency to flooding in times of heavy rain. The more uniform the flow, the smaller will be the expenditure on artificial storage to obtain the highest possible continuous power from a given river.

The importance of having accurate information on the minimum as well as the average rate of flow of any given river has been emphasized above. It is also necessary to know the maximum rate of flow of the river, or the flood discharge, because accommodation must be provided to allow this water to flow away without flooding the surrounding country. When a dam is constructed across a river to impound water for a water-power plant, a weir and spillway must also be provided so that surplus water may escape without passing through the turbines. The size of this spillway will depend upon the extent by which the flood discharge of the river exceeds the flow required.

LESSON 25

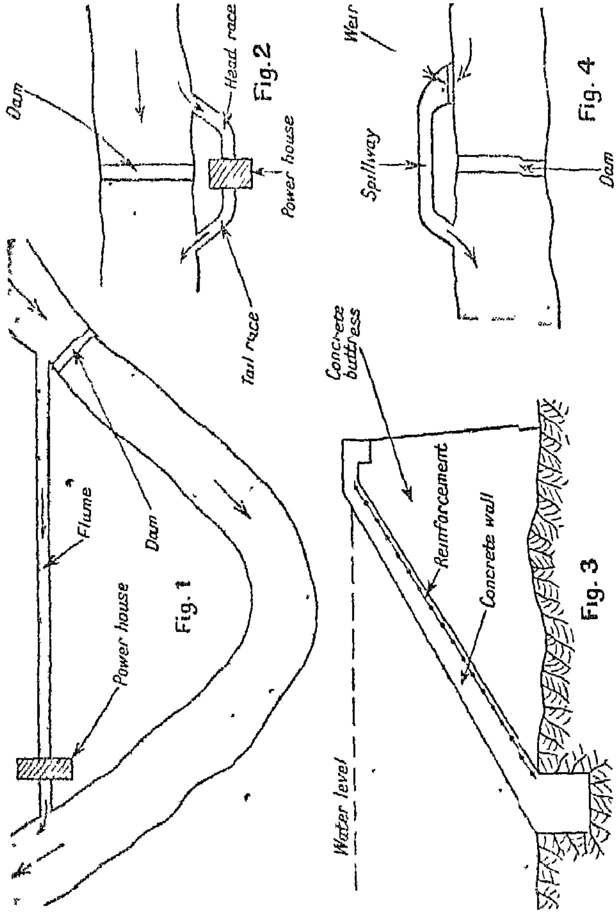
More About Water-Power Schemes

(See plate 4)

WHEN the most convenient site for a power scheme has been decided, other important factors which may then be dealt with concern the position and type of the dam (if a dam is required) and the best position for the power house in relation to the dam. The result to be aimed at is that as much as possible of the available head should be used with the minimum of expense, and each scheme must be considered on its merits.

Water-power schemes may be divided roughly into two classes, high head and low head. There is no clear cut line of demarcation between them, but a high head is generally taken to mean not less than 500 feet. Just as there are two types of steam turbine, so there are two types of water turbines, impulse and reaction. These will be considered in more detail later, but it may be said here that, as in the steam turbine, the impulse type is generally better suited for high velocities of flow and the reaction type for low velocities. Since the velocity of water depends upon the effective head behind it, the impulse type of turbine is usually employed for high head schemes and the reaction type for low heads.

A high head is generally associated with a long pipe-line. For instance, suppose the head is to be 500 feet, then the water must be taken from the river at a point which is 500 feet, measured



WATER-POWER SCHEMES. Fig. 1, pipe-line shortened by cutting across a river bend Fig. 2, arrangement of low-head power station. Fig. 3, elevation of buttressed dam, with sloping upstream face Fig. 4, channel for spill water.

vertically, above the point at which it is discharged back into the river Except in the case of high natural waterfalls, such a drop in water level requires a considerable distance between the points at which the water leaves and re-enters the river.

An arrangement in which the pipe-line or open channel (called a flume) may be shortened by cutting across a sharp bend in a river is shown in Fig 1 The dam may or may not be used, this depends upon the natural fall in the river and the natural arrangements for storage The function of a dam is essentially twofold, to increase the available head of water and to provide storage The power house may be anywhere along the pipe-line according to the natural slope of the countryside

A low head scheme usually involves taking water from one side of a dam and returning it at the other side One possible arrangement is shown in Fig 2, which is a plan view of dam and power house

Different types of construction are adopted depending upon the head of water to be resisted and upon the nature of the sub-soil available as a foundation For low heads solid dams of earth or masonry are used the weight of the dam itself giving it the required stability against the force exerted by the water upon its upstream face For higher heads the buttressed dam may be used In this type, the upstream side is sloping, as shown in Fig 3 so that the weight of the water acting upon the dam helps to keep it in position The face of the dam is of reinforced concrete and it is supported by vertical buttresses at intervals along its length The type shown is not suitable for taking surplus water over the crest of the dam If this were required, a sloping face would be provided on the downstream side also, the space between being hollow except for the buttresses from one face to the other at suitable distances apart

With any dam a spillway must be provided, to allow surplus water to continue on its way down the river In some cases, as mentioned above, the water is allowed to spill over the crest of the dam In other cases the top of the dam is dry, and a special channel is constructed to pass around the dam, as shown in Fig 4 A weir is provided upstream from the dam, the crest of the weir being below the top of the dam The weir and spillway must be of sufficient size to allow flood water to escape without any considerable increase in the height of the river, otherwise flooding might occur farther up the river In some cases special movable weirs are built into the dam itself, in addition to the fixed weir upstream, to allow more water to escape

Dams built for very high heads and short spans are usually of the arch type Where the dam is to be constructed across a

narrow, rocky gorge, the thrust of the water on the face of the dam may be transferred to the sides of the valley. The principle is the same as that underlying the construction of an arch type bridge, considered in Lesson 6 (Volume 1, page 262). A reinforced concrete dam of this type, seen in Fig. 5 (Plate 45), is the main dam of the Maentwrog hydro-electric scheme in North Wales. The space between the footbridge and the crest of the dam provides a spillway for the surplus flow. Towards the far side of the arch may be seen the control gate for the water intake chamber; this control gate is provided so that the entrance to the pipe-line may be shut off. The water from the intake chamber flows through tunnels and pipe-lines, totalling about two miles in length, to the power station situated on the banks of the river lower down. The total head from the top of the dam to the floor of the power house is about 630 feet.

LESSON 26

Water Turbine Installations

(See plate 46)

When *water falls freely from one level to another its* velocity increases, and this increase in kinetic energy may be used in producing rotation of a wheel. In modern turbines the water is directed against suitably arranged vanes on the periphery of a wheel; the vanes cause a change in both the magnitude and the direction of the velocity of the water, and hence a change in the momentum of the water. This change in momentum acts as a driving force on the vanes and causes rotation of the wheel. Thus the energy in the water is converted to mechanical energy at the shaft of the turbine, which may be used to drive machinery, or an electric generator.

In order that the conversion of energy may be carried out as efficiently as possible, all losses must be reduced to a minimum. To this end care must be taken in the design of a turbine to see that all changes in velocity, both in magnitude and direction, are gradual changes, as sudden changes cause loss of energy. Also, the surfaces guiding the flow of the water must be smooth, to reduce the losses through friction; finally, the velocity of the water leaving the turbine should be as small as possible, as any

residual velocity means that the water still contains a corresponding amount of kinetic energy.

Impulse Turbine. There are two main types of turbine, the impulse turbine and the reaction turbine. In the former the whole of the available head is converted to velocity energy before the water reaches the wheel. The water issues from a nozzle with a high velocity and impinges upon a series of buckets attached to the rim of the revolving wheel, the kinetic energy of the water being absorbed in giving the wheel its motion. The pressure inside the turbine casing is uniform, and the water leaving the turbine flows directly into the tail race and so back to the river.

In the reaction turbine only a portion of the head is converted to kinetic energy as the water approaches the turbine wheel or runner, and the pressure of the water is above that at the turbine exit. The difference in pressure at entrance and exit forces the water towards the region of lower pressure; vanes fixed in the turbine runner are situated and shaped in such a way that the speed of flow and direction of the water are changed, and the corresponding loss of momentum of the water reacts upon the vanes and causes the wheel to revolve

The impulse turbine is better suited for high heads than the reaction type, but the latter is better for low heads. For a given power the necessary quantity of water decreases, of course, as the available head is increased. In an impulse turbine it is not usual to use more than one jet on each wheel, but with the reaction type the water may be admitted all around the wheel. Thus the larger quantities of water required at low heads are easily dealt with in the reaction turbine.

Reaction Turbine. The general arrangement of a low-head reaction turbine installation is shown in Fig. 1. The available head in this case is only about 9 ft. The head race is seen on the right, a strainer rack being provided to prevent solid matter and floating débris from entering the turbine. The axis of the turbine is vertical; the water enters at the sides and flows out at the lower end, as shown by the arrows. A concrete-lined chamber is arranged around the entrance to the turbine so that a continuous supply of water is provided to the whole periphery. For higher heads this volute chamber (as it is called) is more often made of cast iron, on account of the higher pressures, but for low heads it is very convenient to form it in concrete, as this gives a better surface finish with reduction in frictional losses.

The water leaving the volute chamber is directed by the guide vanes indicated in the drawing so that it flows on to the vanes of the revolving wheel with as little shock as possible.

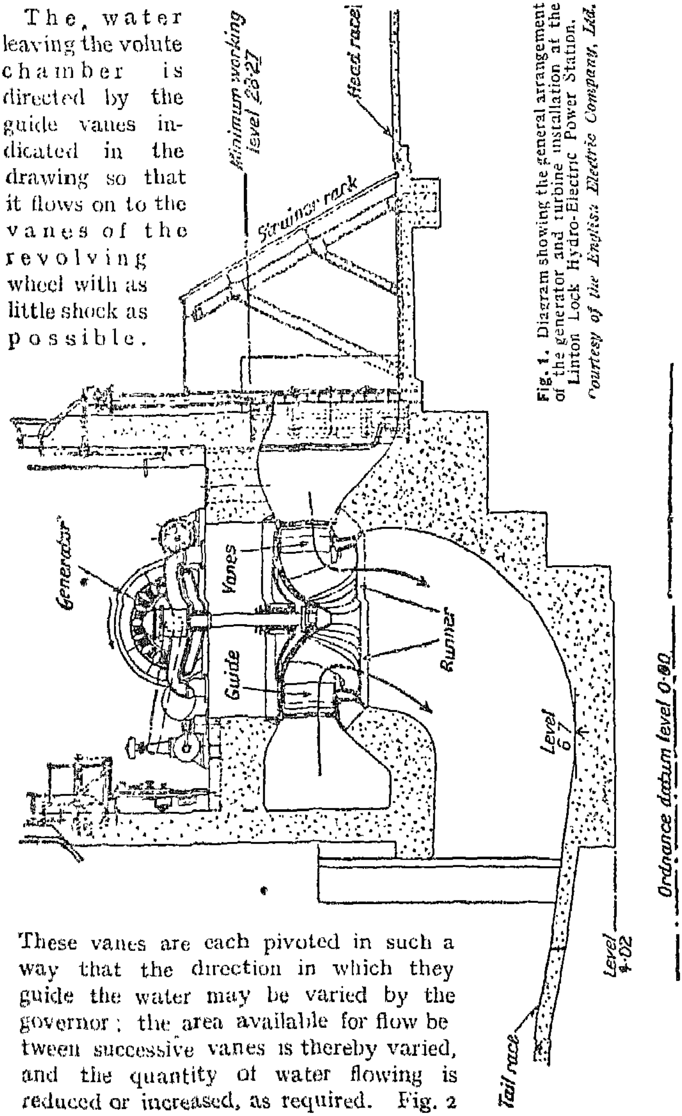


Fig. 1. Diagram showing the general arrangement of the generator and turbine installation at the Linton Lock Hydro-Electric Power Station.
Courtesy of the English Electric Company, Ltd.

These vanes are each pivoted in such a way that the direction in which they guide the water may be varied by the governor; the area available for flow between successive vanes is thereby varied, and the quantity of water flowing is reduced or increased, as required. Fig. 2

(Plate 46) shows the guide vanes in course of erection at the makers' works. The links seen on top of the casing control the inclination of the vanes. Each link is attached at its outer end to a lever fixed to one guide vane, and at its inner end to a ring which is operated by the governor gear through the two rods shown. The guide vanes themselves may be seen below the end cover, which is built into the concrete in such a way (shown in Fig. 1) that the periphery of the guide vanes forms the inner limit of the volute chamber, while the upper side of the end cover is open for inspection from the floor of the power house. In Fig. 2 the spindle of the turbine wheel or runner can be seen projecting up through the cover. Bevel gearing is used to transmit the turbine power to the shaft of the generator, which is in a horizontal position (Fig. 1). The runner itself is illustrated in Fig. 3, which shows how the vanes are shaped and curved in order to change the flow of the water. The photograph shows the inlet side of the runner, on which the guide vanes direct the in-flowing water; the discharge is at the bottom. The turbine develops 430 horse power at 60 rev. per min., the large size of the runner being necessary on account of the low head and the large quantity of water required in consequence.

The power scheme for which this turbine was built is the Linton Lock hydro-electric station of the city of York. Two turbines of 430 horse power and one of 330 horse power were installed in the power house. The weir across the river gives a head of about 9 feet, and the power house is built close beside it. The passage of river traffic is arranged for by a lock and canal leading from one side of the weir to the other.

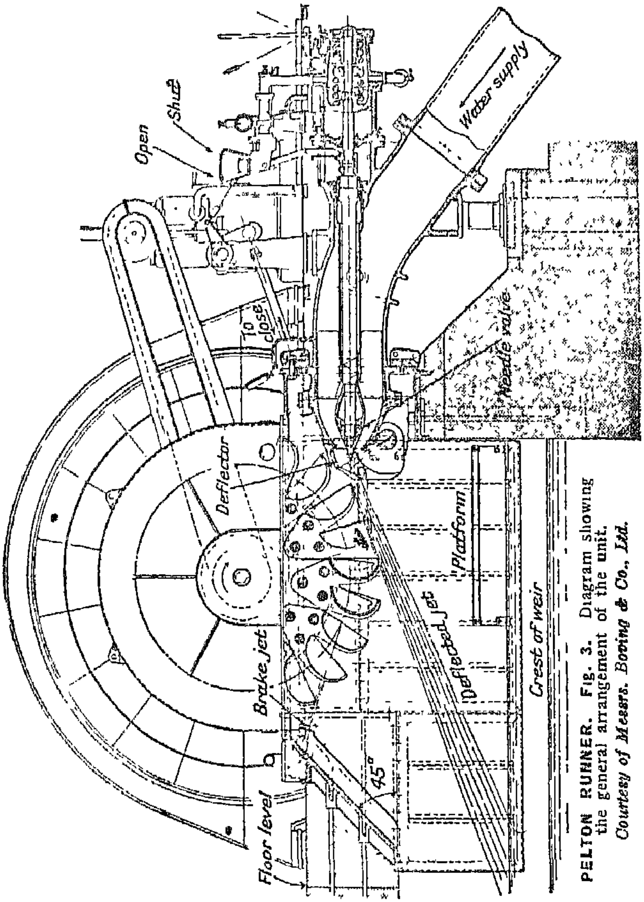
LESSON 27

Two Modern Types of Turbine

(See plate 47)

THE Pelton wheel is the modern form of the impulse turbine. The pressure energy in the water in the pipe line is converted into kinetic energy by discharging the water through a nozzle into a chamber in which the pressure is that acting at the tail race. The issuing jet is directed against a series of buckets attached to the rim of the revolving wheel; these buckets are specially shaped so as to absorb the energy

of the jet. Fig. 1 (Plate 47) is a photograph of a Pelton runner, showing how the buckets are arranged and secured in position.



PELTON RUNNER. Fig. 3. Diagram showing the general arrangement of the unit.
Courtesy of Messrs. Boving & Co., Ltd.

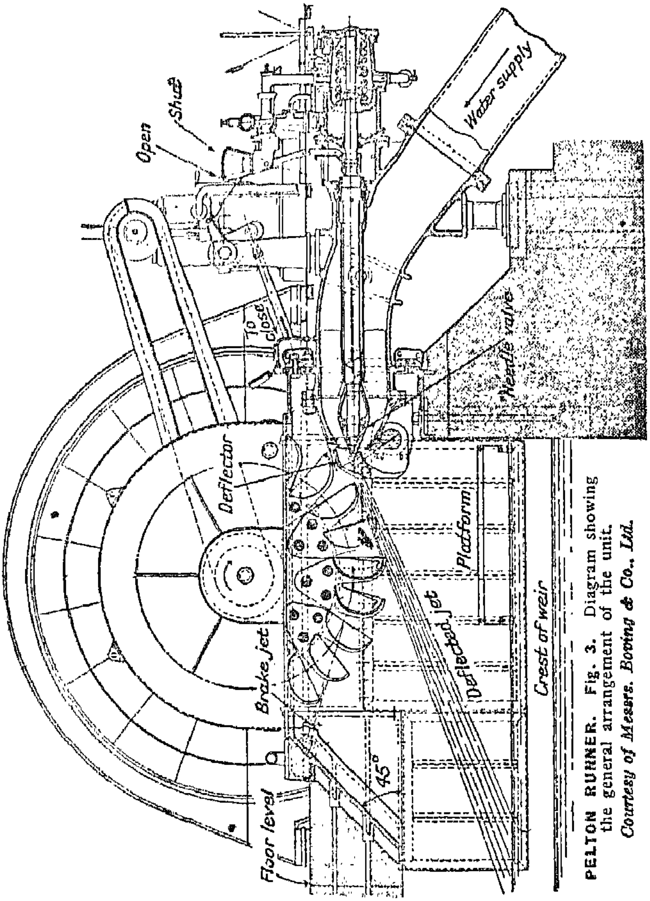
In the case illustrated the buckets were cast in pairs to enable them to be securely attached to the wheel. One of the double buckets is shown separately in Fig. 2. It will be seen that each bucket is divided into two cup-shaped sections by a sharp-edged rib in the central plane of the

wheel. The centre of the jet strikes this rib, so that the stream of water is divided into two parts. The water flows over the smooth, rounded surface of the bucket, and its direction of flow is completely reversed. If the wheel were held stationary the water would be discharged back towards the jet, but if the wheel is revolving at the correct speed the water will have no backward velocity left in it after it has been deflected by the bucket, and it will fall down into the discharge pipe. The lips of the buckets are cut away as shown in the illustrations in order to allow the jet to impinge properly upon the next bucket as the wheel revolves.

A drawing showing the arrangement of the wheel and the nozzle from which the jet issues is reproduced in Fig. 3. The chief point of interest here is the method used to control the quantity of water flowing through the nozzle, in order to vary the power to suit the requirements of the generator. This method is a combination of a jet deflector and a needle valve. The deflector plate is shown just above the outlet from the nozzle, and is hinged on the pin shown just below the nozzle. The deflector plate is connected by a series of links to the governor mechanism and, if the speed rises slightly owing to a reduction in the load, the deflector is moved outwards and downwards into the path of the jet. The stream of water from the nozzle is thus deflected, either partially or wholly, according to the reduction in load. If wholly deflected, it follows the path indicated on the figure.

The deflector is not in this case, however, the only method of regulation. It is, in fact, only a temporary method employed until such time as the main regulator has time to act. The real method of control in this case is the needle valve shown with the point projecting from the mouth of the nozzle. By moving this needle valve forwards or backwards the area available for the passage of the water may be decreased or increased. In many plants the needle valve alone is used for regulation, and in some small plants the deflector plate alone is used. The disadvantage in using a needle valve alone is that care must be taken as to the rate at which the valve is closed. When water is flowing with a high velocity along a pipe its momentum is large; if the water is brought to rest suddenly, as by the closing of a valve, this momentum builds up a high pressure on the upstream side of the valve. This may give rise to the well-known

of the jet. Fig. 1 (Plate 47) is a photograph of a Pelton runner, showing how the buckets are arranged and secured in position.



PELTON RUNNER. Fig. 3. Diagram showing the general arrangement of the unit.
Courtesy of Messrs. Boving & Co., Ltd.

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phenomenon of water-hammer, a sharp blow which is experienced when a water-tap on a long pipe is very suddenly closed. For this reason it is very important that the needle valve should not be closed rapidly, but, on the other hand, it is essential that the governor should act quickly when the load varies, otherwise large variations in speed would occur

These conflicting requirements are met by the temporary use of the deflector plate. The governor gear is so arranged that, as soon as the load falls and the speed begins to rise, the deflector plate is moved first to the required extent and controls the quantity of water impinging on the buckets while the needle valve is being slowly moved forward partially to close the nozzle The deflector plate in itself is not an efficient method of regulation, as it allows water to flow to waste without doing useful work. With the needle valve the quantity of water is reduced and all the water issuing from the nozzle strikes the buckets and is used to its fullest extent.

The brake jet, shown at the left hand side of Fig 3, the diagram in page 312, is directed so as to impinge on the backs of the buckets, and is brought into use when it is required to bring the wheel to rest suddenly

Kaplan Turbine. This is a type of reaction turbine which has come into prominence in recent years, it is, however, a modification to a piece of mechanism familiar to most readers, namely, the screw propeller. The propeller type of turbine has been used before, but it had the disadvantage that the efficiency only reached that of the types described above when developing full power, and fell away rapidly as the load was reduced The reason for this was that the shape and inclination of the blades of the propeller were designed for full load conditions, and gave poor results if the normal flow of water was reduced The same is true for a ship's propeller, but as it is used for most of its life at or near full load the decrease in efficiency at reduced load is not important. In a power station, on the other hand, the demand for power only reaches its maximum for short periods, and perhaps only once or twice a day With any type of power plant it is usual to divide the total power between a number of units, so that when the load on the station falls to the extent of the power of one unit, that unit is shut down, while the remainder operate at their full output, and, therefore, at their maximum efficiency Even when the load variations are confined

to one power unit at a time, however, every effort is made to improve the efficiency of that unit at reduced load.

The old propeller turbines could be designed to give as high an efficiency at full load as the Pelton wheel or the type described in the preceding Lesson, but on account of having fixed blades their efficiency dropped away even when the load was only slightly reduced. In the Kaplan turbine a special mechanism is used to vary the inclination of the propeller blades to suit varying conditions of operation. At any particular load, therefore, the blades may be moved into the position occupied by those of a fixed-blade propeller designed for that load. In this way the turbine is operated at a constant efficiency right down to low loads. It is specially suitable for very low heads where the quantity of water is great for a given power.

A Kaplan runner designed to develop 37 500 horse power with a head of water of about 36 feet and running at a speed of 75 revs. per minute, is shown in Fig. 4 (Plate 47). It consists of four blades attached to a central boss; this boss is fixed to the shaft driving the generator. Inside the boss is housed the mechanism by which the pitch of the propeller is altered to suit varying conditions of load. Each blade is bolted, by the holes shown in the photograph, to a spindle passing through to the inside of the boss, and all four spindles are revolved to the same extent by the operating motor, so that the inclination of each blade is altered by the same amount.

The quantity of water admitted to the circular shaft in which the runner revolves is controlled by guide vanes similar to those used in the reaction turbine described in Lesson 26. When the load falls and the speed begins to rise, the governor operates a mechanism whereby the vanes are moved so as to restrict the flow. At the same time the mechanism inside the runner boss is operated and the blades are moved to the proper inclination corresponding to the quantity of water flowing between the guide vanes.

Our Course in Engineering is continued in Volume 5.

LESSON 17

More About Defective Verbs

In Lesson 16 (Volume 3, page 318) we dealt with the defective verbs, *do, will, shall* and *may*; we now come to the verbs *can, must, ought, dare* and *need* in this category. *Can* is from an old verb *cunnan*, meaning "to know." "I can read" therefore means "I know how to read": e.g. "He knew to sing" ("Lycidas"). We have this meaning still preserved in "to con," and in the Scottish "to ken." "Cunning" is the old imperfect participle of this verb, and *couth* the past participle (cf. *uncouth*, which means *unknown* and therefore *strange*).

As *can* originally meant "to know," it required no infinitive: cf. "They *can* well on horseback" ("Hamlet"); "Other prayer *can* I none" ("Lay of the Last Minstrel"). Bacon even has "not to *can*."

Can is always a notional or principal verb: e.g. "I *can* write" (i.e. "I am able to write"); "I would if I *could*" (i.e. "I would if I were able").

CONJUGATION OF VERB "CAN."

INDICATIVE MOOD.

Present.

I can	We can
Thou canst	You can
He can	They can

Past.

I could	We could
Thou couldest *or* couldst	You could
He could	They could

SUBJUNCTIVE MOOD.

Present.	*Past.*
(None.)	(Same as Indicative.)

No Infinitive, Imperative, or Participles.

Like *can*, the verb *must* is always a notional verb It has no inflexions for tense or person all the persons of each number of each of the two indicative tenses being alike *must* It has no subjunctive infinitive imperative or participles

Ought is the past indefinite tense of *owe* Thus, in Shakespeare's ' King Henry IV, the hostess says " He said this other day you *ought* (owed) him a thousand pounds It is now used as a present in the sense of moral obligation as " I *ought* to be a better man

Owe originally meant *to own, to possess*, as " This is no mortal business nor no sound that the earth *owes* " (" Tempest ") , ' I am not worthy of the wealth I *owe* " (' All's Well ')

Owe to be in debt is quite regular *I owed I shall owe*, etc

In the verb *dare* (to venture) the third person singular of the present indicative is properly ' he dare, ' *not* " he dares " The reason is that " I dare is an old *past* tense and is not really a present at all e g " Mine unworthiness that *dare* not offer, etc ' (' Tempest) We now use ' I durst " as the past tense of *dare*, followed by the infinitive without *to* as he durst not do it " When *dare* is a transitive verb meaning ' to challenge " it is a perfectly regular weak verb

When *to need* means " to lack, to be in want of," it is perfectly regular But when it means " to be under the necessity of doing a thing," the third person singular present indicative is often ' he *need*," not " he *needs*," as, " he need not go " Contrast this with " he *needs* brains "

Wit (to know) has present, *I wot*, past, *I wist*, and present participle, *witting* or *wotting* This verb is not used now except in the infinitive *to wit*, in the sense of " namely " , together with *wit*, the verbs *quoth*, *methinks*, *list*, *hight*, *dight* and *worth* are practically obsolete in Modern English, except in deliberately archaic or poetic diction

Quoth is used only in the first and third persons singular, for ' said I," ' said he ' Examples " *Quoth* the raven, ' Nevermore " " ' To tame your fierce temper *quoth* she "

Methinks is only used in the forms *methinks* and *methought* *List* in the archaic *melists* (it pleases me) and *him-listed* is an impersonal verb It is also used personally as " The wind bloweth where it *listeth* "

Hight is used only in the meaning " was called " *Dight* means, decked, adorned *Worth*, expressing a wish, is used only in the

LESSON 17

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Can is always a notional or principal verb: e.g. "I *can* write" (i.e. "I am able to write"); "I would if I *could*" (i.e. "I would if I were able").

CONJUGATION OF VERB "CAN."

INDICATIVE MOOD.

Present.

I can	We can
Thou canst	You can
He can	They can

Past.

I could	We could
Thou couldest *or* couldst	You could
He could	They could

SUBJUNCTIVE MOOD.

Present.	*Past.*
(None.)	(Same as Indicative.)

No Infinitive, Imperative, or Participles.

Like *can*, the verb *must* is always a notional verb. It has no inflexions for tense or person, all the persons of each number of each of the two indicative tenses being alike *must*. It has no subjunctive, infinitive, imperative or participles.

Ought is the past indefinite tense of *owe*. Thus, in Shakespeare's "King Henry IV," the hostess says, "He said this other day you *ought* (= owed) him a thousand pounds." It is now used as a present, in the sense of moral obligation, as "I *ought* to be a better man."

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Owe, "to be in debt," is quite regular: *I owed, I shall owe*, etc.

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When *to need* means "to lack, to be in want of," it is perfectly regular. But when it means "to be under the necessity of doing a thing," the third person singular present indicative is often "he *need*," not "he *needs*," as, "he need not go." Contrast this with "he *needs* brains."

Wit (to know) has present, *I wot*, past, *I wist*, and present participle, *witting* or *wotting*. This verb is not used now except in the infinitive *to wit*, in the sense of "namely"; together with *wit*, the verbs *quoth*, *methinks*, *list*, *hight*, *dight* and *worth* are practically obsolete in Modern English, except in deliberately archaic or poetic diction.

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Methinks is only used in the forms *methinks* and *methought*. *List* in the archaic *melists* (it pleases me) and *him-listed* is an impersonal verb. It is also used personally as "The wind bloweth where it *listeth*."

Hight is used only in the meaning "was called." *Dight* means, decked, adorned. *Worth*, expressing a wish, is used only in the

third person singular present subjunctive, as: " Woe *worth* the day " = " May woe befall the day."

EXERCISE.

Explain every *should* and *would* in the following:

She would often say " Would I were a man. I *should* have been, for then I would have shown the world a lesson it would never forget." I would reply that I should not attempt to argue with her lest she should get angry; but I now often think that I should have done so. For perhaps I should have convinced her that it would not have been so easy. Should I, or should I not, I wonder?

LESSON 18

Strong Verbs

ENGLISH verbs are divided into *strong* and *weak*, according to the manner in which they form their Past Indefinite tense. Verbs that form this tense by modifying the vowel of the present tense (without adding any suffix) are said to belong to the *strong* conjugation—as: *shine, shone.* The past participle of all strong verbs originally ended in *-en*, and this ending still remains in many of them (sometimes in the form of *-n*)—as: *break, broke, broken.*

Verbs that form their past indefinite by adding the suffix *-ed*, *-d*, or *-t* to the present tense are said to belong to the *weak conjugation*, as: *treat, treated; feel, felt.* When the present tense ends in *e*, *d* only is added, as, *love, loved.* The vowel *y* preceded by a consonant becomes *i* before this suffix, as: *bully, bullied; pay, paid.* A single final consonant preceded by a single vowel is usually doubled before the suffix, as: *drug, drugged; travel, travelled.* The past participle of weak verbs is usually the same in form as the past indefinite. If the present tense ends in *d* or *t*, the suffix is often dropped, and present, past, and past participle have all the same form, as in the following example: *cost, cost, cost.*

The most interesting strong verbs, particularly those that present any difficulty, are now given, grouped according to their vowel modification.

VERBS OF THE STRONG CONJUGATION

	Past	Past Participle.
	bound	bound
	found	found
	ground	ground
	wound	wound
	clung	clung
	flung	flung
	slung	slung
	slunk	slunk
	stuck	stuck
	strung	strung
	swung	swung
	wrung	wrung
	began	begun
	drank	drunk (-en)
	rang	rung
	sang	sung
	sank	sunk (-en)
	span, *or* spun	spun
	shrank	shrunk (-en)
	sprang	sprung
	stank	stunk
	swam	swum
	won	won
	blew	blown
	grew	grown
	knew	known
	threw	thrown
	drew	drawn
	held	held
	fell	fallen
recline)	lay	lain
	slew	slain
	saw	seen
	drove	driven
	rode	ridden
	rose	risen
	smote	smitten
	chid	chidden, *or* chid
	hid	hidden, *or* hid

Present.	*Past.*	*Past Participle.*
slide	slid	slid
strive	strove	striven
strike	struck	struck
thrive	throve	thriven
write	wrote	written
bite	bit	bitten
eat	eat (pron. *et*), *or* ate	eaten
beat	beat	beaten
bid (to order)	bade, *or* bid	bidden, *or* bid
give	gave	given
forsake	forsook	forsaken
shake	shook	shaken
take	took	taken
come	came	come
bear	bore	borne, *or* born
break	broke	broken
tear	tore	torn
wear	wore	worn
weave	wove	woven
speak	spoke	spoken
steal	stole	stolen
swear	swore	sworn
choose	chose	chosen
freeze	froze	frozen
fly	flew	flown
abide	abode	abode
awake	awoke	awoke
stand	stood	stood
tread	trod	trod, *or* trodden
sit	sat	sat
get	got	got
hang	hung	hung
run	ran	run
burst	burst	burst
shoot	shot	shot
seethe	sod	sodden, *or* sod
spit	spat, *or* spit	spit
fight	fought	fought

LORD BURGHLEY [illegible] William [illegible] Eliz[abeth] [illegible] trust[ed] [illegible] until [illegible] BRITISH HISTORY [illegible]

[illegible]

THOMAS CROMWELL ([illegible] – [illegible]) [illegible] son of a blacksmith, [illegible] the [illegible] of Wolsey and thence [illegible] that [illegible] Henry VIII. For some [illegible] first minister, but [illegible] high treason and [illegible] Hill. BRITISH HISTORY [illegible]

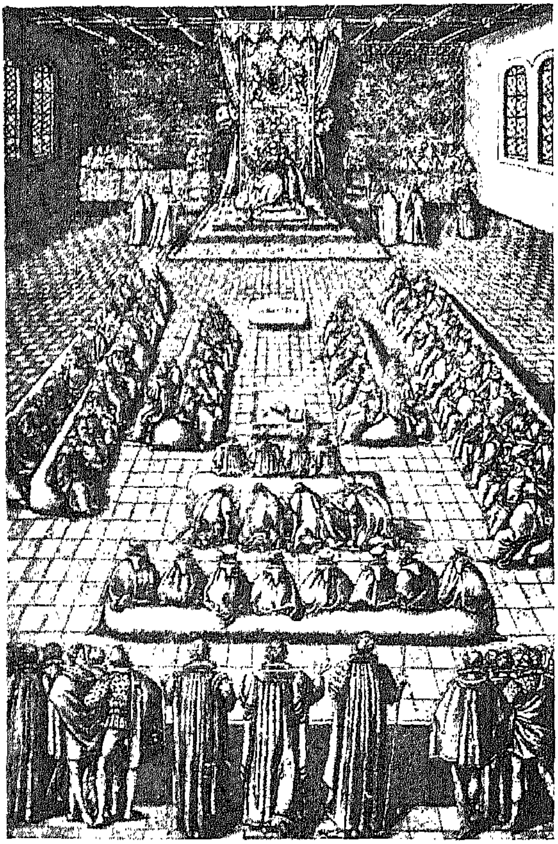
Nat[ion]al Portrait Gall[e]ry

DEATH MASK OF ELIZABETH [illegible] with [illegible] death mask [illegible] BRITISH HISTORY 10

[illegible]

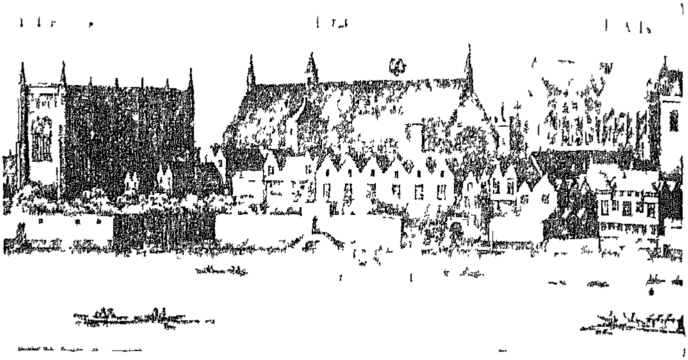
ELIZABETHAN CAPTAINS. Left : Sir Walter Raleigh (c. 1552–1618), who played a considerable part in the early colonization of North America, and in many respects was the incarnation of the spirit of the Elizabethan era. He was executed for " treason " in 1618. Right : Sir Francis Drake (c. 1545-1596), who first circumnavigated the world (1577-80), and was one of the leaders of the English against the Spaniards. BRITISH HISTORY 10

THE GUNPOWDER PLOT. One of the best-remembered incidents in English history is the plot devised by certain Roman Catholic conspirators for the blowing up of Parliament on November 5, 1605. This engraving by Crispin Van der Passe shows the conspirators in conference. BRITISH HISTORY 11



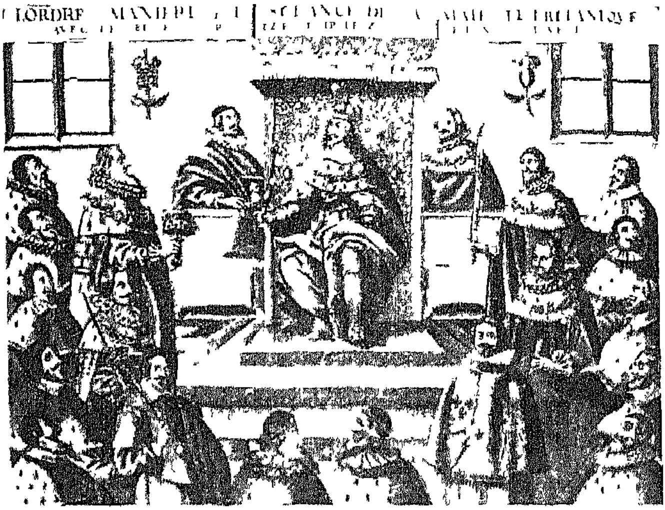
THE HIGH COURT OF PARLIAMENT IN THE REIGN OF JAMES I. This engraving from R. Glover's "Nobilitas Politica et Civilis," 1608, shows James I enthroned in the House of Lords, and is probably the earliest authentic representation of such a meeting. Earls, barons, and *bishops are grouped round the Chancellor's seat and the masters of* chancery and the clerks are ranged in rows of four immediately facing his Majesty. In the foreground the Commons are seen separated from the Lords by a barrier, and the central figure in their midst is the speaker. BRITISH HISTORY II

British Museum



PARLIAMENT HOUSE IN THE TIME OF CHARLES I This engraving, by W. Hollar, shows the old House of Parliament as it appeared to the artist in 1641. Originally a chapel founded by Stephen, the building became a meeting place of the House of Commons under Edward IV, until whose reign its sessions had been held in the chapter house of Westminster Abbey (right). The Commons held their meetings in S. Stephen's chapel until 1834, when it was destroyed by fire. BRITISH HISTORY 12

British Museum



CHARLES I ON HIS THRONE This picture of Charles I in the House of Lords is taken from a pamphlet which appeared in [illegible]. Behind the King on the right is the Chancellor, on the left stands the Treasurer. The official holding the crown is the Great Chamberlain and the Constable holds the sword. A herald, usher and nobles occupy the foreground. BRITISH HISTORY 12

NOTES.—*Drunken, sunken* and *shrunken* are now used only as adjectives, as: a *drunken* man; *sunken* rocks, *shrunken* flannel.

Fall, fell, fallen is intransitive; but the kindred verb *to fell* is transitive, weak, and regular, as: "The woodman *felled* the tree."

Borne means *carried*; *born* is used of *birth*, chiefly after the verb "to be" Examples: "Their voices were *borne* by the winds"; "I was *born* in this village."

Awake, as a strong verb, is intransitive, meaning "I wake up." When it is transitive, meaning "I rouse someone," it is weak, and has *awaked, awaked* for its past tense and past participle. Similarly with *hang*; when intransitive it is strong, as: "he *hung* there for three hours"; when transitive, it is weak—as: "the murderer was *hanged*."

Seethe, meaning *to boil*, is very seldom used now, except in a figurative sense, as: "a seething mass of men." The original sense is seen in the expression, "And Jacob *sod* pottage" (Genesis xxv, 29). The past participle *sodden* now means "soaked through." *Seethe* is now usually weak, making *seethed seethed*.

LESSON 19

Final Study of the Verb

WITH this Lesson we complete the verb section—the most important section of all to those who would speak and write English well. New verbs which have been introduced into English from foreign sources are conjugated like weak verbs. These include verbs of French origin, such as *passed, finished*, etc., and more recent scientific borrowings such as *electrified, radiographed*, etc.

Some verbs of the weak conjugation shorten the vowel as:

Pres.	*Past.*	*P. Part.*	*Pres.*	*Past.*	*P. Part.*
bleed	bled	bled	meet	met	met
breed	bred	bred	read	read (*pr.* red)	read (*pr.* red)
feed	fed	fed	speed	sped	sped
lead	led	led	light	lit	lit

Some keep the vowel, but they change the final *-d* into *-t*:

Present.	*Past.*	*Past Participle.*
bend	bent	bent
lend	lent	lent
rend	rent	rent
send	sent	sent
spend	spent	spent
wend	went, *or* wended	wended
build	built	built, *or* builded
blend	blended	blent
gild	gilt, *or* gilded	gilt, *or* gilded
gird	girt, *or* girded	girt, *or* girded

Some show no change at all. The following have the same form throughout: *Cast, cost, cut, hit, hurt, knit, let, put, rid, set, shed, shred, shut, slit, split, spread, thrust,* and *bid* (meaning "to offer at an auction").

Some shorten or otherwise alter the vowel:

Present.	*Past.*	*Past Participle.*
beseech	besought	besought
buy	bought	bought
catch	caught	caught
bring	brought	brought
sell	sold	sold
seek	sought	sought
teach	taught	taught
think	thought	thought
tell	told	told
work	worked, wrought	worked, wrought
can	could	—
may	might	—
will	would	—
shall	should	—
bereave	bereft, *or* bereaved	bereft
creep	crept	crept
deal	dealt	dealt
dream	dreamt, *or* dreamed	dreamt
feel	felt	felt
flee	fled	fled
hear	heard	heard
keep	kept	kept

Present.	*Past.*	*Past Participle.*
kneel	knelt	knelt
lean	leant, *or* leaned	leant
leave	left	left
lose	lost	lost
mean	meant	meant
sleep	slept	slept
sweep	swept	swept
weep	wept	wept
lay	laid	laid
say	said	said
shoe	shod	shod

VERBS OF MIXED CONJUGATION.

Present.	*Past.*	*Past Participle.*
shear	sheared, shore	sheared, shorn
cleave (to split)	clove, cleft	cloven, cleft
dig	dug, digged	dug, digged
crow	crew, crowed	crowed
hew	hewed	hewn, hewed
lade	laded	laden
lose	lost	lost, lorn (*forlorn*)
melt	melted	melted, molten
mow	mowed	mown, mowed
rive	rived	riven, rived
saw	sawed	sawn, sawed
shape	shaped	shapen, shaped
shave	shaved	shaved, shaven
shew, *or* show	shewed, *or* showed	shewn, shown, showed, *or* shewed
sow	sowed	sown, sowed
strew	strewed	strewn, strown, strewed
swell	swelled	swollen, swelled
wax (to grow)	waxed	waxed, waxen
do	did	done
go	[went]	gone

NOTES. *Went*, used as the past tense of *go*, is the past tense of *wend*—as in "to wend one's way."

Crew (from *crow*) is rarely used now, and only of the literal crowing of a cock—e.g. "the cock *crew*." When used of the crowing of babies, etc., the past tense is always *crowed*. Some of the strong past participles are used only as adjectives—e.g. a *molten* image, the *cloven* hoof, a *shaven* head.

Clothe, *have* and *make* form *clad*, *had* and *made*, which are contracted from *clothed*, *haved* and *maked*.

Tight and *straight* (adjectives) are weak past participles of *tie*, *stretch*. *Distraught* is an irregular past participle of *distract*. *Fraught* is the past participle of the obsolete Middle English verb *fraghten*, to load. (Cf. Modern English, to freight).

Lie and Lay. Much confusion arises between the verbs *lie* and *lay*, and their differences should be well noted by comparing the principal parts:

Present.	*Past.*	*Past Participle.*
(1) lie (to recline)	lay	lain
(2) lay	laid	laid

To lie is strong and intransitive. *To lay* is weak and transitive.

Examples of *to lie*: The sofa that I *lie* on is comfortable; he *lay* where he fell; I *have* never *lain* on a softer bed.

Examples of *to lay*: *Just lay the parcel on the table; he laid down the book; hens lay eggs; that hen has laid five eggs this week.*

By using *lay* with the reflexive pronoun *myself* (*me*), etc., as object we have an alternative to (1): I lay myself (me) down, for I lie down. I laid myself (me) down, for I lay down. I have laid myself (me) down, for I have lain down.

LESSON 20

An Account of the Adverb

JUST as adjectives qualify nouns, so adverbs modify or limit verbs, as, "He bowed to me *politely*." "He gives *twice* who gives *quickly*." This usage has been extended, and adverbs can now modify adjectives and other adverbs in addition to verbs, as: "*Too* many cooks spoil the broth" (*too* modifying the adjective *many*), "He struck me *very* forcibly" (one adverb *very* modifying another, *forcibly*).

Adverbs, like adjectives (from which they are mostly formed), are usually classified according to their meaning; just as

adjectives are divided into qualitative, quantitative, and relational, so we can divide adverbs. Thus:

1. ADVERBS OF QUALITY: *Well, ill, badly*, and all the adverbs in *-ly* derived from adjectives: *how, however, so, as, likewise*, etc. (sometimes called adverbs of manner).

2. ADVERBS OF QUANTITY: *a.* Degree: *Very, nearly, almost, too, quite, enough, rather, much, more, most, little, less, least, only, but, just, even, any, the* (as in "*the* more *the* merrier"). Also the adverbs of affirmation and negation: *Not, no, nay, aye, yea, yes.*

b. Repetition of Time: as, *once, twice, thrice, often, seldom, always*, etc.

3. ADVERBS OF RELATION, showing: *a.* Time: *Now, then, after, before, soon, ago, instantly*, etc.

b. Place and Arrangement: *Firstly, secondly, thirdly, here, there, hither, thither, hence, thence, inside, outside, up, down*, etc.

c. Cause and Consequence: *Why, therefore, wherefore, accordingly, consequently*, etc.

It will be noticed that some of the words appearing in this list of adverbs have previously appeared as other parts of speech. *As*, for example, was included under relative pronouns; and *much, little, no, any*, were included under adjectives. To determine what part of speech a word is in a given sentence, we must consider the purpose it serves. Thus, "this is the same *as* that" (relative pronoun = "this is the same which that is"); "*as* I spoke the sun came out" (adverb denoting the time of the action). Again, "Give him *no* peace" (adjective), "this is *no* better than that" (adverb). Similarly, *much, little*, and *any* before comparatives are adverbs.

Formation of Adverbs. 1. From Adjectives. Most adverbs are formed by adding *-ly* to the corresponding adjective—e.g. *wild, wildly; cheerful, cheerfully.* The termination *-ly* = like.

Adjectives ending in *y* preceded by a consonant change *y* into *i* before *-ly*: e.g. *hearty, heartily; speedy, speedily;* but: *shy, shyly; gay, gaily.*

Adjectives ending in *-le* change the *e* into *y*: e.g. *noble, nobly; horrible, horribly.* When the adjective already ends in *-ly* the same form is generally used for the adverb: e.g. the adverb of *godly* is usually *godly* ("We should live soberly, righteously and *godly* in this present world." So also *likely*: "a likely

story" (adjective); "he will very *likely* come" (adverb). Other adverbs derived from adjectives are *once, twice, thrice* (for *ones, twyes, thries*), *unawares.* Some adjectives, in addition to those ending in *-ly*, are used as adverbs without any change of form: e.g. "run *fast*," "stand *firm*," "strike *deep*," "*pretty* good."

2. From Nouns. *Needs* (as in "If I must needs leave you"), *whiles, sideways, lengthways, straightways, noways,* are genitive cases of nouns. *Whilom* ("at whiles," "formerly") and *seldom* are dative cases plural of Old English *hwil* (= space of time), and *seld* (= rare). Other adverbs derived from nouns are *headlong, sidelong, piecemeal* (meal = part), *sometimes, always, perhaps, otherwise, midway,* etc. Many adverbs are compounds of the preposition *a* (meaning *on*) and a noun, as *afoot, abreast, aside, asleep;* while some are compounds of other prepositions with nouns, as *betimes* (by times), *besides, indeed.*

3. From Pronouns. *Thus, then, than; here, hither, hence; there, thither, thence; where, whither, whence; why, how* (for *whow*), and all the other adverbs formed from the relative pronouns, such as *wherefore, whereat, wherein, whereby,* etc.

These adverbs, that are derived from the relative pronouns (with the addition of *as* and *than*), are *connective* or *conjunctive* adverbs, that is, they retain the connective power which we have seen belongs to relative pronouns. A connective adverb introduces a subordinate clause and modifies the predicate of this clause.

Negative Adverbs. *Not* is shortened from *nought* or *naught,* and literally means "in no whit, in no degree." In Old and Middle English, *ne* (= *not*) is employed before the verb, and a form corresponding to *naught* after the verb, the two negatives strengthening each other; thus, in Robert of Gloucester's Chronicle (A.D. 1298) we find "*Ne* be thou naught so sturne" ("Be thou not in any way so stern"), and in Chaucer's "Canterbury Tales" we have

> "There was also a Doctour of Physik,
> In all the world *ne* was there *none* him like."

Also "Nor hath not one spirit to command" ("Tempest").

In Modern English, two negatives, so far from strengthening each other, neutralize each other.

No and *nay* are from *na*, meaning *never*, while *aye* (affirmative) is from *a*, meaning *ever* (cf. *for aye*, meaning *for ever.* "This

world is not for aye," "Hamlet"). *Yes* is from Old English *gese* (pronounced *yēs-ĕ*), from *gēa* (yea) and *swā* (so).

Comparison of Adverbs. Most adverbs are compared by prefixing *more* and *most* to the positive, as *willingly, more willingly, most willingly.* But a few, and especially those which have the same form as the corresponding adjectives, are formed by the suffixes *-er, -est*; as:

Positive.	*Comparative.*	*Superlative.*
firm	firmer	firmest
fast	faster	fastest
soon	sooner	soonest
early	earlier	earliest

The following are irregular (see "Comparison of Adjectives," Vol. 2, Lesson 7, p. 239):

Positive.	*Comparative.*	*Superlative.*
well	better	best
badly, evilly, *or* ill	worse	worst
much	more	most
far	farther	farthest
forth	*further*	*furthest*
nigh *or* near	nearer	nearest, next
late	later	latest
	latter	last
[rathe, *adjective*]	rather	—
—	ere	erst
lief	liefer	—

Rathe meant *quick, early; rather,* therefore, means *quicker, earlier, sooner.* Milton in "Lycidas" has "the *rathe* primrose" (adjective).

Ere is the Old English *ǣr*, a comparative adverb of time. It is now used mainly as a conjunction. *Erst*, from *ǣrest*, means *formerly.*

Adverbs are usually placed as near as possible to the words they modify, and generally *before* an adjective, or other adverb, and *after* a verb. For emphasis, however, an adverb may precede the verb, and even stand as the first word of a sentence.

Our Course in English Language is continued in Volume 5.

LESSON 27

English Prose: Its First Eight Centuries

The student confronted for the first time with even an elementary work on English prose may well ask himself why he should study it. What is the use, for example, of an anthology of English prose? Is it compiled in order that the reader of it may be enabled to form some idea of the origin and development of the language at various periods of its history? Yes; and no. Philological considerations alone do not enter into such a work. There is as much fascination attached to the study of the growth of a language as there is to the pageant of history.

We apply our minds to classic prose, not only for the light it sheds upon the time in which it was written; not merely because of its intrinsic value as a means of knowledge, but also because of its style. And for yet another reason—which some would place above all the rest—because behind the style is a living man. Herein, for the true student of literature, is the secret charm of our standard literature, and especially of our standard prose

We learn, sooner or later, that the eloquence, the rhythm, the colour, the tone, the deft management of the period, are largely modelled by the great masters of English prose upon the works of men who wrote in Greece and Rome and the East some twenty centuries or more ago. But that is no cause for withholding our tribute of grateful admiration. What is allowed to the plastic artist, the painter, the sculptor, the architect, cannot be denied the artist in words. All highly developed art is rooted in classical tradition.

When we approach a work of living prose we may be certain that behind it is a great man, and something more—something of the character of the best of that man's contemporaries, of the spirit of the age in which he lived. Genius is the same in all ages, and writers in the rudest times, as well as those in more polished and enlightened eras, reached those limits beyond which the faculties of the human mind seem unable to penetrate. Thus, the elements of thought are only conditioned, not governed, by the outward circumstances of their expression.

Verse has been, certainly in English, far ahead of prose in the matter of settled law. Hence we can imitate the rhythm of Spenser without seeming old-fashioned. No cadence in modern verse is more pure, more perfect, than that of Shakespeare's sonnets and lyrics. But the prose of the masters and makers of it is even more personal; it cannot be imitated.

All that can be attempted in the space available here is to indicate where the student must look for the leading examples of English prose, and to point out, as briefly as may be, the principal stages of our prose development.

The chief characteristic of Anglo-Saxon prose reflects what is a chief characteristic of the English character, practicality. The language was direct and simple. Another point to be borne in mind is that right up to and including the sixteenth century our prose writers, beginning with the Venerable Bede (673–735), were in the main translators. Their works were for the most part educational, religious, and historical, as is the "Anglo-Saxon Chronicle," in character. Alfred the Great (849–901) was a translator himself and the cause of translation in others.

Alfred sought to give his people peace, and he laboured manfully to effect their intellectual improvement. He desired that at least every free-born youth who possessed the means should "abide at his book till he could well understand English writing." He sought to spread wide the learning which was then the monopoly of the clergy. Ballads and poems England already possessed. Prose she had none. He aimed at the rendering of all useful books "into the language which we all understand."

This language has been described as one of the finest and purest forms of Teutonic speech. Into it Alfred translated, or, rather, paraphrased, in an epitomized form, the "Universal History" of Orosius, a Spanish author of the fifth century; the "Historia Ecclesiastica" of the Northumbrian monk Bede; the "Pastoral Rule" of Pope Gregory, and the "De Consolatione Philosophiae" ("On the consolation afforded by philosophy") of Boethius, a Roman philosopher and martyr of the sixth century. Some idea of the English that Alfred wrote may be gleaned from the following example, which is given with modernized lettering, from the "De Consolatione."

"Hit gelamp gio, thætte, an hearpere wæs on thære theode the Thracia hatte. Thæs nama wæs Orpheus. He hæfde an swithe ænlic wif; sio wæs haten Eurydice."

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This passage has been rendered thus:

"It happened formerly that there was a harper in the country called Thrace. His name was Orpheus. He had an excellent wife called Eurydice."

The work from which these lines are quoted was also translated by Chaucer. Its theme is the mutability of all earthly things save virtue; it belongs to that rare order of immortal works that have been written in prison.

To the development of Old English a period is placed covering the Danish and Norman conquests and on through the years 1150–1350. During the first of these last two centuries the inflections were broken up, and in the second numerous French words were incorporated in the English language. Middle English, of which Chaucer was the great literary artificer, flourished from 1350 to 1550, and since the latter date our language and literature are classed as Modern English.

As was the case with the Anglo-Saxon and Early English writers, their successors of the fourteenth century concerned themselves chiefly with the work of translation. Several of Chaucer's works are of this nature—two of the famous "Canterbury Tales": "The Tale of Melibeus," borrowed from Albertano of Brescia, and "The Persones (Parson's) Tale," a sermon derived from Frère Lorens; the unfinished "Treatise on the Astrolabe"; and his "Boethius."

Though the Norman conquest introduced Norman-French as the language of the court and the cultured classes, while Latin remained the language of the clergy and that in which many learned works were written, the native dialects merged into one another, and ultimately into the Middle English tongue. That the French influence was by no means a negligible quantity is evident if we examine the work of Chaucer alone; but the native English as successfully resisted the Norman-French invasion as our native drama in the sixteenth century rose superior to the dictates of the "University scribes," who sought to shackle it with the dead weight of classical tradition. Following upon the death of Chaucer, however, the French wars and the Wars of the Roses once more set back the clock of English literary activity, and there is but little of interest to chronicle, save the introduction of the printing press by William Caxton (c. 1422–91), till we reach the age of the Tudors, whence may be dated the beginning of Modern English.

LESSON 28

Early Masters of English Prose

ONE example of the manner in which the English appropriated French literature is to be found in the anonymous translation of "The Voyage and Travels of Sir John Maundeville" of Jehan de Bourgogne, a work which is still read on account of its naive descriptions of the marvellous. But especially interesting is it to ponder the influence of the romantic legends of the Norman poets known as the Trouvères. These deal with Alexander the Great, King Arthur and the Knights of the Round Table, Charlemagne, and the Crusaders.

The origin of the Arthurian legends is Celtic—partly Welsh and partly Breton. "La Mort d'Arthure" of Sir Thomas Malory (1470) so delighted the heart of Sir Walter Scott that he described it as being indisputably the best prose romance of which the English language can boast. Many writers of the 19th century, Tennyson among them, are the eternal debtors of Malory, whose work, as printed with all the affection of a great and sympathetic craftsman by William Caxton, played no small part in the making of Elizabethan prose

For his black-letter folio of this work—of which only two copies are known to exist, though a number of reprints are obtainable—Caxton wrote a preface, in which he said, in language that indicates the rapidity of the change from Chaucer's :

"I have after the symple connyng that God hath sente to me, under the favour and correctyon of al noble lordes and gentylmen, enprysed to enprynte a book of the noble hystoryes of the said kynge Arthur, and of certeyn of his knyghtes, after a copye unto me delyvered, whyche copye syr Thomas Malorye dyd take oute of certeyn bookes of Frensshe and reduced it into Englysshe. And I, accordyng to my copye, have doon sette it in enprynte, to the entente that noblemen may see and lerne the noble acts of chyvalrye, the jentyl and vertuous dedes, that somme knyghtes used in tho dayes, by whyche they came to honour, and how they that were vycious were punysshed, and often put to shame and rebuke, humbly bysechying al noble lordes and ladyes, wyth al other estates, of what estate or degree they been of, that

shal see and rede in this sayd book and werke, that they take the *good and honest actes in their remembrance, and to folowe the* same."

A favourite passage from Malory's own text is his account of the passing of Arthur. How English it is, apart from the spelling, may be seen from the following modernized extract:

"And when they were at the water-side, even fast by the bank hoved a little barge with many fair ladies in it, and among them all was a Queen, and they all had black hoods, and they all wept and shrieked when they saw King Arthur. 'Now put me into the barge,' said the King; and so they did softly. And there received him three Queens, and in one of their laps King Arthur laid his head, and then that Queen said, 'Ah, dear brother! why have ye tarried so long from me? Alas, this wound on your head hath caught overmuch cold.' . . . Then Sir Bedivere cried, 'Ah, my lord Arthur, what shall become of me now ye go from me, and leave me here alone among mine enemies?' 'Comfort thyself,' said the King, 'and do as well as thou mayst; for in me is no trust to trust in. For I will go into the Vale of Avillon, to heal me of my grievous wound. And if thou hear never more of me, pray for my soul.'"

Malory's monumental work, following that of Chaucer and Gower, gave to English literature something of the glamour of chivalry and romance; and this influence was followed in its turn by the translation of Froissart's "Chronicles" by Lord Berners (or Bourchier) (1467–1533).

Jean Froissart, like one of his own heroes, set out on his travels in quest of adventure. He visited England twice, in the reigns of Edward III—when he was secretary to Queen Philippa for some years—and of Richard II; he was the guest of David Bruce in Scotland; he journeyed in Aquitaine with the Black Prince, and was in Italy, possibly with Chaucer and Petrarch. Ten years before his death he settled in Flanders. His "Chronicles" deal with the period between 1326 and 1400, and are drawn from his travels and experiences. They are among the most vivid and picturesque things in European literature. Sir Walter Scott considered his history had less the air "of a narrative than of a dramatic representation."

The student of fifteenth century England should not omit to pay some attention to the "Paston Letters" (1422–1509). These documents, which are about a thousand in number and were

not printed in full until the present century, were written during the reigns of Henry VI, Edward IV, Richard III, and Henry VII, by members of an East Anglian family. They not only throw a flood of light on the social customs of fifteenth century England, but serve to indicate that the civil strife of the Wars of the Roses which then divided families did not altogether crush out either the desire for, or the means of, learning.

Sir Thomas More (1480-1535) was a man whose thoughts were far in advance of his time. His theories were essentially those of a humane man and a philosopher; his practice, as Chancellor of Henry VIII, was at variance with his avowed sympathies, but undoubtedly he was bound by the legal conventions of his period. He was beheaded for refusing to acknowledge any other head of the Church than the Pope. His best known work, the "Utopia," a political satire, was written in Latin, and translated into English by Ralph Robynson thirty-five years later. It deals with the social defects of English life, and pictures an imaginary island where communism is the rule, education common to the sexes, and religious toleration general. The title is derived from two Greek words, meaning "Nowhere." More also wrote a number of works in English, of which the most notable is his "Historie of Edward the Fifth and Richard the Third."

As our Anglo-Saxon forbears fought against the influence of Norman-French, so Roger Ascham (1515–68), the tutor of Queen Elizabeth and afterwards her secretary, reflected the native English spirit in his vigorous prose and his antagonism to the "Italianate Englishman," who modelled his conduct and his studies on what he or others brought back from Italy in those early days of Continental intercourse and travel. Ascham was devoted to the old English pastime of archery, and wrote a defence of it in English, "Toxophilus," which he dedicated to Henry VIII, adding an address to the gentlemen and yeomen of England, in which occurs a passage that forms at once an apology for and a defence of his native tongue:

"As for the Latin or Greek tongue, everything is so excellently done in them that none can do better; in the English tongue, on the contrary, everything is in a manner so meanly, both for the matter and handling, that no man can do worse. . . .

"He that will write well in any tongue must follow this counsel of Aristotle, to speak as the common people do, to think as wise men do."

There are several important works on education which belong to the sixteenth century, but Ascham's "Scholemaster" is the first in point of time, and contains not a little advice the value of which is of a permanent character. One of the truths that he urges is being propagated in our own day: namely, the need of awakening in the mind of the pupil an interest in his work.

In this connexion the following excerpt from the "Toxophilus" has interest, and serves also as an illustration of Ascham's style:

"If men would go about matters which they should do and be fit for, and not such things which wilfully they desire, and yet be unfit for, verily greater matters in the commonwealth than shooting should be in better case than they be. . . . This perverse judgment of men hindereth nothing so much as learning, because commonly those that be unfitted for learning be chiefly set to learning. As if a man nowadays have two sons, the one impotent, weak, sickly, lisping, stuttering, and stammering, or having any mis-shape in his body, what does the father ot such one commonly say? This boy is fit for nothing else but to set to learning and make a priest of. . . . This fault, and many such like, might be soon wiped away if fathers would bestow their children always on that thing whereunto nature hath ordained them most apt and fit."

Henry VIII, who encouraged Ascham, must have it placed to his credit also that he gave similar aid to Sir Thomas Elyot (c. 1490–1546), who wrote "The Boke named the Governour," the first on the subject of education written and printed in English, and the first Latin-English dictionary.

LESSON 29

Religion's Part in the Shaping of English Prose

(See plate 48)

As poetry, in a chronological sense, takes precedence of prose in the history of English literature, so religious works precede secular in influencing the growth of English prose. The services of the early translators of the Bible cannot be overestimated. First among these translators was John Wycliffe (c. 1325–84). It is important to remember, however, that neither the "Wycliffe Bible" nor any of its successors was the work of one man, although "Wycliffe's Bible,"

"Tyndale's Bible" and "Coverdale's Bible" are common terms. According to Cardinal Gasquet, Wycliffe's Bible was the work of the English bishops.

Before Wycliffe's time only portions of the Scripture had been translated into English. Wycliffe—to follow the accepted story—set himself a few years before his death to the task of producing the first complete English Bible. By 1382 he had completed the New Testament. His friend, Nicholas of Hereford, translated most of the Old Testament and the Apocrypha. John Purvey, a pupil of the Reformer, revised the work four years after Wycliffe's death. The translation (or paraphrase), which was made from the Vulgate (or Latin version) was originally issued in manuscript form; of this 150 copies are still extant. Written as it was for the common people, it is remarkable to find with how much ease "Wycliffe's Bible" can still be read. Wycliffe was a Yorkshireman, and we are told that when, some years ago, several long passages were read to a congregation in his native county, not only were they understood by the hearers, but almost every word was found to be still in use.

The work of Wycliffe was carried on and improved by William Tyndale (c. 1492–1536), a pupil of Erasmus, the great co-worker with Martin Luther in the Reformation. When Erasmus published his Latin version of the New Testament in 1516 he declared:

"I long that the husbandman should sing portions of them (the Gospels) as he follows the plough, that the weaver should hum them to the tune of his shuttle, that the traveller should beguile with their stories the tedium of his journey."

Tyndale, who was a good Greek scholar, studied Hebrew for the purpose in hand, and, while consulting the Vulgate, went back to the originals as the basis of his version. He was helped in his task by a fugitive friar named Roy and others. It was "Tyndale's Bible" which, revised by Miles Coverdale (c. 1488–1568)—the first complete printed English Bible—and edited and re-edited as "Cromwell's Bible" (1539), and "Cranmer's Bible" or "The Great Bible" (1540), was set up in every parish church in England, in some cases being chained to the lecterns, or reading desks—hence the term "Chain Bible."

The Bible, to quote Stopford Brooke, "got north into Scotland and made the Lowland English more like the London English. It passed over to the Protestant settlements in Ireland." After

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The Bible, to quote Stopford Brooke, "got north into Scotland and made the Lowland English more like the London English. It passed over to the Protestant settlements in Ireland." After

its revision in 1611—there had been printed meanwhile the "Geneva Bible," sometimes referred to as the "Breeches Bible" from the rendering of Gen. iii. 7, a work handier in size than its predecessors, in Roman type and with the text divided into verses pithily annotated—it went as the Authorised Version with the Puritan Fathers to New England and fixed the standard of English in America.

In Edward VI's reign Thomas Cranmer (1489–1556) edited the English Prayer Book (1549–52). "Its English," Stopford Brooke notes, "is a good deal mixed with Latin words, and its style is sometimes weak or heavy, but on the whole it is a fine example of stately prose. It also steadied our speech."

To examine the influence of the Bible on English writers from Shakespeare's time to Swinburne's would be to specify nearly all the best work of our greatest writers. Scarce any writer of note but has either acknowledged its inspiration or shown trace of it in his work.

The development of English rhetoric and English philosophic and religious thought during the 16th and 17th centuries may be studied in the writings of Hugh Latimer (c. 1485–1555), Bishop of Worcester, whose sermons well sustain the homely and direct character of his native tongue; John Knox (c. 1514–72), the Scottish reformer and historian; John Foxe (1516–87), whose "Actes and Monuments, commonly known as "Foxe's Book of Martyrs," "gave to the people of all over England a book which, by its simple style, the ease of its story-telling, and its popular charm, made the very peasants who heard it read feel what is meant by literature"; Richard Hooker (c. 1553–1600), author of "The Laws of Ecclesiasticall Politie," a great theologian whose memory is enshrined in "Walton's Lives," and whose character is fitly indicated on his monument at Bishopsbourne, Kent, as "judicious"; and Jeremy Taylor (1613–67), Bishop of Down and Connor, the author of "Holy Living" and "Holy Dying," and a voluminous writer who, in the words of his friend Bishop Rust, of Dromore, "had the good humour of a gentleman, the eloquence of an orator, the fancy of a poet, the acuteness of a schoolman, the profoundness of a philosopher, the wisdom of a chancellor, the reason of an angel, and the piety of a saint."

Equally important to the student of English literature are the writings of Thomas Hobbes (1588–1679), a philosopher who applied the principles of geometry to the judgement of human

conduct and who, in his "Leviathan," "De Cive," "Human Nature," and other works showed himself to be "the first of all our prose writers whose style may be said to be uniform and correct and adapted carefully to the subjects on which he wrote"; Thomas Fuller (1608-61), the style of whose best-known work, "Worthies of England," shows admirable narrative faculty, "with a nervous brevity and point almost new to English, and a homely directness ever shrewd and never vulgar"; and Sir Thomas Browne (1605-82), a Norwich physician and author of "Religio Medici," than whom, according to Sir Edmund Gosse: "* among English prose writers of the highest merit there are few who have more consciously, more successfully, aimed at the translation of temperament by style."

John Bunyan (1628-88), the inspired tinker, most zealous of Puritans and author of some sixty books, is chiefly famous for his masterpiece "The Pilgrim's Progress," in which Man tests all the delights of the world and all the resources of the intellect, rejects them as dangerous or inadequate, and finds religion the only sure road through life, even though beset with doctrinal dangers. The book sprang at once into fame, 100,000 copies being sold during the author's life-time. The first part of it was written in Bedford gaol, where he had been imprisoned as a Nonconformist preacher under the Conventicle Act. Next to "Pilgrim's Progress," his two most famous books are "The Holy War" and "Grace Abounding," the former of which contains variations on the theme of his masterpiece, while the latter is an intimate autobiography, in which his deeply religious experiences are vividly described.

Another eminent Puritan writer is Richard Baxter (1615–91), whose Life may be studied an as example of self-help by the side of Bunyan's, and the style of whose many writings is one of the finest specimens extant of vigorous English. Of even greater value than Baxter to the general reader are John Locke (1632–1704), author of "Two Treatises of Government," "An Essay Concerning Toleration," "An Essay Concerning Human Understanding," and a work especially to be commended to students on "The Conduct of the Understanding," and a philosopher who is spoken of as "the unquestioned founder of the analytic philosophy of mind"; and Gilbert Burnet (1643–1715), bishop of Salisbury, and author of a "History of the Reformation" and a "History of My Own Times."

Regarded in this brief summary, the works of these theological and philosophical writers may appear uninviting; but the general reader no less than the student cannot neglect them all without missing a fruitful part of the great and rich field of our national literature. Foxe's "Book of Martyrs," Taylor's "Holy Living" and "Holy Dying," Hobbes's "Leviathan," Fuller's "Worthies," Browne's "Religio Medici," Bunyan's "Pilgrim's Progress" and "Grace Abounding," Locke's "Human Understanding"—these especially, and others that we have named, are classics of which every one who aspires to a sound appreciation of our literature should have first-hand knowledge, reading them in the first instance perhaps for what they have to teach of philosophy and theology, and then learning to love them for their charm of style, their wisdom, their vision, and their humanity.

LESSON 30

English Prose in the 17th Century

(See plate 48)

Both Spenser and Shakespeare wrote prose. Spenser's "View of the Present State of Ireland" is written in a most pleasing style. Shakespeare's prose has been the theme of many commentators. The student is recommended to study the "men in buckram" section of "Henry IV." The "Arcadia" and the "Defense of Poesie" of Sir Philip Sidney (1554–86) should also be studied in this connexion.

The first popular English history in the language is "The History of England to the Time of Edward III" of the poet Samuel Daniel (1562–1619). After Daniel's work may be considered the "History of the World," written in the Tower by Sir Walter Raleigh (1552–1618), and to be read for its human and personal interest more than on account of its intrinsic value as history. Edward Hyde, first Earl of Clarendon (1609–74) friend of poets like Jonson and Waller, wrote a "History of the Rebellion." This was modelled on the style of the Roman historian Tacitus, and is notable for its biographical value.

The "Life of Colonel Hutchinson," the Puritan, by his widow Lucy Hutchinson (b. 1620), is one of the most delightful of biographies, with a historical character for subject, and, taken up as a study, will be read through for the charm and simplicity of the narrative.

To the domain of history and antiquarian study belong the writings of William Camden (1551–1623), John Selden (1584–1654), John Stow (c. 1525–1605), Raphael Holinshed (c. 1520–80) and William Harrison (1534–93). Mention must also be made here of the invaluable diaries of Samuel Pepys (1633–1703) and John Evelyn (1620–1706). Pepys's diary in the original, comprehending six volumes, was closely written in shorthand by the author, and belonged to the collection of books and pictures bequeathed by him to Magdalene College, Cambridge. The shorthand MS. was not deciphered till early in the 19th century by the Rev. J. Smith, and first published in an abridged version in 1825. Besides throwing a brilliant light on the manners, personages and events of the Restoration period—the diary deals with the years 1659–1669—it presents an amazing, because absolutely honest, psychological study of Pepys himself.

John Evelyn's diary (first published in 1818) covers a period of seventy years; his intellect remained fresh and vigorous to the last. His pen was a busy one, whether used in descriptions of Court life after the Restoration, travel, or the countryside.

The "Familiar Letters" of James Howell (1593–1666) contain much contemporary history and display both brilliant wit and keen observation. They are the earliest written series of English letters which may be styled literary. With them must be mentioned the exquisite epistles of Dorothy Osborne (1627–95), afterwards the wife of Sir William Temple, diplomatist and essayist.

The meaning of the word essay is "a testing." As we understand it to-day, an essay is a valuation of a subject, usually of a literary or social nature, from the standpoint of the writer. The "Essays of Montaigne," the translation of which by John Florio (c. 1553–1625) preserves for us a vigorous and perennially delightful example of Elizabethan prose, hardly come within the limits of the essay as we understand the word.

The Elizabethan and Jacobean pamphlets were, in a sense, essays, but we see in them perhaps more distinctly the beginning of the modern newspaper, because they were published for controversial purposes. They form in themselves a somewhat absorbing branch of literary and historical study.

A number of the writers of these pamphlets also wrote tales, so that while the "Euphues" of Lyly is generally regarded as the earliest English novel, it is not quite isolated as an example

of English prose narrative Even if we leave Sidney's "Arcadia" out of the question, there are the tales as well as the pamphlets of Robert Greene, of Thomas Lodge (c 1558-1625) whose "Rosalynde" inspired Shakespeare's "As You Like It" and Thomas Nash (1567-1601), whose "Jack Wilton" provided the prototype of Falstaff

Londoners who desire to learn how their predecessors lived three centuries ago will find a world of entertainment in "The Gull's Hornbook" of Thomas Dekker (1570-1637) The most interesting and permanent of all the pamphlets is the "Areopagitica"—so named after the Areopagus the open-air court of Athens in which matters of public concern were freely ventilated—a trenchant plea for the liberty of the printing press, by John Milton (1608 74) Another of the great poet s prose works was the "Doctrine and Discipline of Divorce," in which he attacked the sacramental view of marriage and argued that incompatibility of character or contrariety of mind should be constituted just grounds for divorce

The first of the English essayists proper is Francis Bacon (1561-1626) The student can have no better guide than is provided in the fiftieth of Bacon's fifty-eight "Essays"—the one entitled "Of Studies"—full-charged with wise and practical advice, perfectly exemplifying Bacon's method and perspicuity of style. "Histories make men wise poets witty, the mathematics subtile, natural philosophy deep, moral grave, logic and rhetoric able to contend" Of Bacon's "Essays" Hallam rightly declared that it "would be derogatory to any educated man to be unacquainted with them" They deal with the essentials of life as recorded by a man of the acutest intellect, they fail only where the intellectual predominates unduly over the emotions His counsels of life are wise, but, as Henry Morley said of them "they are not the whole abstract of human wisdom, and sometimes, not often they sink where they should rise"

Next to Bacon s "Essays" should be ranked the "Discoveries" of Ben Jonson, which Swinburne prefers before them, and Professor Saintsbury describes as coming "in character as in time midway between Hooker and Dryden" Jonson's "Discoveries" have been too long neglected There is a great deal in them concerning education and study that will generously reward the most careful attention

After Jonson, considered as an essayist, come Abraham Cowley (1618-67), whose language is at once simple and graceful; and Sir William Temple (1628-99), somewhat pompous, a little full of pretentious learning, but distinctly a predecessor of Addison.

It is difficult to classify the "Anatomy of Melancholy" of Robert Burton (1577-1640), but Johnson and Charles Lamb both greatly admired it; it is full of quaint and curious learning, of a profound earnestness, irony, and somewhat bitter humour. Burton explains that he wrote of melancholy "to comfort one sorrow with another . . . make an Antidote out of that which was the prime cause of my disease." The "Microcosmographie" of John Earle, bishop of Salisbury (c. 1601–65), is at once of social and philosophical value, but stands, like the "Anatomy," by itself. Three other books that demand notice are the "Lives" and "Compleat Angler" of Izaak Walton (1593-1683), the first a gem of literary biography—containing the five lives of Donne, Wotton, Hooker, Herbert and Sanderson, and one of Dr. Johnson's favourite books—the second one of the first of "country books"; and the "Autobiography" of Lord Herbert of Cherbury (1583–1648), which Swinburne placed among "the hundred best books."

The place of honour as the first English critic belongs to John Dryden. In the words of Lowell, Dryden, more than any other single writer, contributed, as well by precept as example, to free English prose from "the cloister of pedantry," and by his masterly handling to give it "suppleness of movement and the easier air of the modern world."

"His style (Lowell continues) has the familiar dignity so hard to attain, perhaps unattainable except by one who feels that his own position is assured. Swift was as idiomatic, but not so elevated; Burke more splendid, but not so equally luminous. That his style was no easy acquisition, though, of course, the aptitude was innate, he himself, tells us, when he tells us that the Court, the College, and the Town must be joined in the perfect knowledge of a tongue."

The introductions to Dryden's works are specially worthy of study. The famous "Essay on Dramatic Poesy" has already been commended. Nearly the whole of Dryden's criticisms will be found edited by W. P. Ker in his "Essays of John Dryden."

LESSON 31

Great Journalists in the Age of Anne

(See plate 49)

WHAT the prose of the eighteenth century may lack in colour and warmth, as compared with the prose of the seventeenth century, it gains in general smoothness, perspicacity and correctness. It has been styled "aristocratic," and this description is in the main a true one. But at the period with which we are now to deal the "aristocracy of intellect" was to a great extent employed in the furtherance of ends more practical, or at least more partisan, than literary. These ends were in part political, in part ecclesiastical, in part ethical. Thus the literature of the time must be studied in connexion with its political, religious and social history. Journalism, which had its rise in the controversial pamphlets of Elizabethan and Jacobean times, received in the eighteenth century a new impetus, and the novel assumed a more definite shape.

Defoe. Daniel Defoe (c. 1659–1731) is often regarded as the father of modern English journalism, and the forerunner of Richardson and Fielding. Today, except as the author of two or three books, one of them of world-wide repute, Defoe is half forgotten. In his lifetime, however, he played many parts, and over 250 distinct works bear his name. Numbers of pamphlets and treatises flowed from his pen. Educated as a Dissenter, he had the cause of Protestant Nonconformity at heart. As an able and vigorous controversial writer, he supported William III's Whig policy against the High Church Tories. In the famous treatise, "The Shortest Way with Dissenters" (1702), Defoe with scathing satire advocated the complete extirpation of the dissenters, and this with such surface plausibility that his High Church opponents were at first deceived, and afterwards being the more enraged against him because of their deception, secured his committal for trial at the Old Bailey, where he was sentenced to be fined and imprisoned during the queen's pleasure, and to stand three days in the pillory. Viewing him there, the sympathetic crowd, instead of insulting him, drank his health.

"Robinson Crusoe," and the "Journal of the Plague Year" (fictitious but a masterpiece of reality) are enough to secure for

Defoe pre-eminence as a master of the art of literary illusion. He had defects. He was curiously heedless of chronology; he was weak, on the whole, as a delineator of character. But he was an essential "realist," with creative imagination; immensely vigorous, clear-sighted and dramatic, he remains one of the greatest of English writers. Sir Walter Raleigh, critic and professor of English, says:

"With Defoe the art of fiction came to be the art of grave, imperturbable lying, in which art the best instructor is the truth. And it was to no reputed master of romance, but to recorders of fact, biographers, writers of voyages and travels, historians and annalists, that Defoe served his apprenticeship."

As the author of "Captain Singleton," "Moll Flanders," "Colonel Jack" and other works of a kindred character, Defoe stood brilliant sponsor to the novel of crime. In 1704 he started a "Review," which was the forerunner of "The Tatler," "The Spectator" and "The Rambler." He has been called the typical journalist. His "Robinson Crusoe," written when he was fifty-eight, is as immortal as "The Pilgrim's Progress" or "Don Quixote." Like these two works and one other that we shall have to mention almost immediately, "Robinson Crusoe" may be read by the young on account of the narrative alone, and by older readers as an allegory. The sequel, less well known and greatly inferior, possesses considerable interest.

Swift. As a pamphleteer Jonathan Swift (1667–1745) affords an interesting companion study to Defoe. Swift was, however, by far the greater man. His power as a pamphleteer may be gauged by a consideration of the famous "Letters," signed "M. B. Drapier," and familiarly known as "The Drapier Letters." In these compositions he attacked the iniquitous "job" by which, in 1772, a certain William Wood, a hardwareman and a bankrupt, was granted a patent for supplying Ireland with copper coin. The "Drapier Letters" defeated this project; and though it is often said that the ensuing popularity of their author among the Irish people was unpalatable to him, his bequests to Irish charities seem to negative the idea that he had no sympathy for the people amid whom his lot was for a long time cast; he always sympathized with sufferers from injustice and had "a perfect hatred of tyranny and oppression," wherever he found it.

"The Tale of a Tub" is the most comprehensive example of all that is characteristic of his prose style. As sailors were

supposed to throw out a tub to a whale to prevent it from colliding with their ship, so Swift thought by his "Tale" to afford such temporary diversion to the wits and freethinkers of his day as to prevent them from injuring the State by the propagation of wild theories respecting religion and politics. But his satiric genius, his fiery imagination and his keen eye for "the seamy side" imparted to "The Tale of a Tub" qualities that disguised his avowed object, and at the very outset placed an insurmountable obstacle in the way of his ecclesiastical preferment

"The Battle of the Books," which, with "The Tale of a Tub," helped to make Swift famous, takes a witty part in a controversy that was raging amongst his literary contemporaries over the respective claims of modern and ancient literature.

Something like one-fourth of Swift's most remarkable work, "Gulliver's Travels," and a great part of his other writing are marred by coarseness. But of "Gulliver's Travels" enough is so delightful as romance as to rival both "Robinson Crusoe" and "The Pilgrim's Progress" Important as a satire, "Gulliver's Travels" has a distinct value as an autobiography. While Defoe excelled in the art of making fiction read like fact, Swift, with the finest skill, cultivated a drastic simplicity and homeliness of style, the accumulated effect of which was so formidable as to afford a permanent object-lesson in the art that conceals art where the writing of nervous English prose is concerned. But the fact must not be ignored that, with all its carefully calculated simplicity, the English of Jonathan Swift is never pedestrian or devoid of sparkle or variety.

Students of Swift's life will find in his work much that reflects his unhappy experiences. They will be especially indebted to the "Journal to Stella" (Esther Johnson, whose tutor he was) for many valuable pages of autobiography and for many side-lights on the manners of the time A staunch friend, in spite of his intermittent bitterness of spirit, his correspondence with Pope and Gay also affords authentic biographical material.

Steele and Addison. Sir Richard Steele (1672–1729), the friend and schoolfellow of Joseph Addison (1672–1719), was, like Swift, born in Ireland, but in this fact lies the sole resemblance between the saturnine Dean of St. Patrick's and the genial "scallywag" who originated "The Tatler," wrote part of "The Spectator," founded "The Guardian" and worshipped Addison.

In 1709 Steele started "The Tatler," anonymously. It was a small sheet, sold for a penny, appearing three times a week, and designed to expose "the false arts of life, to pull off the disguises of cunning, vanity and affectation, and to recommend a general simplicity in our dress, our discourse, and our behaviour." Part of "The Tatler" was devoted to news. When his pen-name of Isaac Bickerstaff, which he borrowed from a diverting pamphlet by Swift, became useless as a disguise, Steele founded "The Spectator." "The Tatler" extended to 271 numbers, of which Steele wrote 188; his friend Addison contributed 42, and they were jointly responsible for 36. "The Spectator," which was published daily, ran to 635 numbers, of which Addison wrote 274 and Steele 240.

The wholesome effect of these publications on the manners and morals of the eighteenth century can hardly be exaggerated. Both the style of writing and the tone of conversation were improved as a result of their influence. Contrary to the custom of the time, women were treated in Steele's pages with genuine respect. It is generally conceded that while Addison's style is the more finished, Steele's is more marked by liveliness of invention. Addison usually wrote at leisure, Steele often in a "white heat." The papers took the form sometimes of moral and critical discourses, sometimes of short stories of domestic life, in the writing of which, and as an essayist, Steele excelled.

The plan of "The Spectator" was laid at a club, and in the second number, written by Steele, we are given the first sketches of the members. It is a remarkable testimony to the skill of Steele's work that the characters stand out so clearly before us. The immortal baronet Sir Roger de Coverley is understood to be Steele's invention. Steele, as Hazlitt remarked, seems to have gone into his study chiefly to set down what he observed out of doors. Addison, on the other hand, drew most of his inspiration from books.

Not the least of Addison's services to literature was the attention he gave in "The Spectator" to Milton. These papers should be studied by all who desire to appreciate the style and value of literary criticism in Addison's time. On the whole we read Addison today not so much for the value of what he has to say as for the way in which he says it.

That his style is not without its defects goes without saying. He sacrificed everything to elegance, that is to rhythm or melody

of phrase. He shows, too, a somewhat limited vocabulary at times, and is apt to repeat unnecessarily his ideas and his images. Occasional looseness of construction must also be attributed to him ; but in the essay this is not without its advantages, helping to lightness of touch, which is scarcely possible where the writer aims at rounded periods or stately, slow-moving sentences. There are not wanting those who think that Addison has long been something of a fetish with writers on literary style—" read an essay of Addison's every day " has been the injunction of our literary mentors for generations—and that in the not very distant future his chief interest will be historic. But such authorities as Johnson and Macaulay have weight concerning the high qualities of Addison's limpid style. Addison's sentences, according to Johnson, have neither studied amplitude nor affected brevity ; his periods, though not diligently rounded, are voluble and easy. " Never," said Macaulay, " had the English language been written with such sweetness, grace and facility." And if in the future his influence on individual students is less immediate, its effect on 18th-century prose can never be gainsaid.

LESSON 32

Great Writers of the Johnsonian Age

(See plate 50)

SAMUEL JOHNSON (1709-84), poet, essayist, dramatist, biographer, critic, novelist, lexicographer, and the " great Cham " of English literature, the autocrat before whom every " quill-driver " quailed, cannot be considered here in relation to his unrivalled position as a great and wise talker. The student must be referred to James Boswell's " Life of Samuel Johnson, LL.D." as the only one way of realizing Johnson's greatness. If one's leisure will not permit of the considerable task of reading it in its full extent of six hundred thousand words an abridgement will serve.

As to Johnson's influence on prose literature, Macaulay says: " His constant practice of padding out a sentence with useless epithets till it became as stiff as the bust of an exquisite ; his antithetical forms of expression, constantly employed even where there is no opposition in the ideas expressed ; his big words wasted on little things ; his harsh inversions, so widely

different from those graceful and easy inversions which give variety, spirit, and sweetness to the expression of our great old writers—all these peculiarities have been imitated by his admirers, and parodied by his assailants, till the public has become sick of the subject."

Gibbon, the historian of Roman decadence, lived to write; Johnson, an infinitely greater man, wrote to live. Today, Johnson's "Lives of the Poets" are read more, perhaps, than anything he wrote, but not for the accuracy of their data or their infallibility of judgement. They disclose to us not fine literary instinct so much as fine human sympathy.

His prose tale of "Rasselas, Prince of Abyssinia," written to defray the cost of his mother's funeral, has been aptly described as a prose version of his poem on "The Vanity of Human Wishes." According to Boswell, Johnson told his intimate friend, Sir Joshua Reynolds, that he composed "Rasselas" in the evenings of one week, sent it to press as it was written, and had never since "read it over." His great "Dictionary" was the first of its kind. It stands almost alone as the work of one man. Its value and influence have been great; and even today, except for its weakness on the side of etymology, a weakness due to the fact that Johnson's Latin learning was not approached by his knowledge of Anglo-Saxon, it is a standard book of reference. The ordinary reader should have some acquaintance with the "Lives of the Poets", and "Rasselas" he is not likely to miss. For the rest, to know this grand old character in Boswell's biography is, as it was to love Sir Richard Steele's "Aspasia," "a liberal education."

The friendship between Steele and Addison was not greater than that between Johnson and Oliver Goldsmith (1728–74). But no greater contrast could be imagined than that afforded by the writings of the two men. Sir Edmund Gosse says:

"In prose style, as in poetic, it is noticeable that Goldsmith has little in common with his great contemporaries, with their splendid burst of rhetoric and Latin pomp of speech, but that he goes back to the perfect plainness and simple grace of the Queen Anne men. He aims at a straightforward effect of pathos or of humour, accompanied, as a rule, with a colloquial ease of expression, an apparent absence of all effort or calculation."

Goldsmith's prose approximates to that of Addison. The best examples of it are to be found in his "Citizen of the World" and

"The Vicar of Wakefield." The first-named work consists of a series of letters supposed to have been written by a Chinaman resident in London, who was jotting down his experiences for the benefit of his friends in the Far East. The idea was not original, and it has since been imitated by innumerable writers, but the delightful wit and humour of Goldsmith's work have never been excelled. "The Vicar of Wakefield," Goldsmith's chief prose work, is dealt with in another Lesson in this Course, one of several concerned with the history of the English novel.

The period now under consideration, dominated as it was by humanism and intelligence, is naturally rich in historians and philosophers. George Berkeley, Bishop of Cloyne (1685–1753), was a man whose life, apart from his writings, is full of interest. As a philosopher he aimed at the overthrow of materialism (*see* Lessons 11 and 12 in Philosophy, volume 3, pages 554 and 557). He was an acute and original thinker, possessed a style of great force and elegance, and he is one of our most accomplished writers of dialogue.

Joseph Butler, Bishop of Durham (1692–1752), was the author of a work on the "Analogy of Religion, Natural and Revealed, to the Constitution and Course of Nature," which won for him the name of "the Bacon of Theology," and remains a standard work in its own department. David Hume (1711–76) was distinguished as an essayist, a philosopher (*see* Lesson 11 in Philosophy), and a historian. Possessing wonderful clearness of mental vision, his style is marked by exceptional lucidity. An opponent of popular government, he was yet the first of our writers to recognize the importance of the social and scientific as well as the constitutional and political factors in the making of history. His influence as a philosopher was most appreciable in Scotland and Germany

The greatest of English historians, Edward Gibbon, the son of a Hampshire gentleman, was born April 27, 1737. After a preliminary education at Westminster, and fourteen "unprofitable" months at Magdalen College, Oxford, a whim to join the Roman Church led to his banishment to Lausanne, where he spent five years, formed his taste for literary expression, and settled his religious doubts in a profound scepticism. It was in 1764, while musing amid the ruins of the Capitol of Rome, that the idea of writing "The Decline and Fall of the Roman Empire" first started into his mind. The vast work was completed in 1788.

"A Study in Literature," written in French, and his "Miscellaneous Works," published after his death, which include "The Memoirs of his Life and Writings," complete the list of his literary labours. He died on January 16, 1794.

The manner in which Gibbon contrived a literary style that fitted the magnitude of his theme remains one of the marvels of our literature. Much nonsense about its "pomposity" has been written. It moves with becoming gravity and produces a sense of formality which is impressive without becoming wearisome, and must, by that token, be most ingeniously varied without any appearance of effort at variety. There is a wonderful illusion of continued progress in the narrative, even when the essence of it was concerned with things that are static. One is impressed with the drama of history; the historian seems by some subtle process of art to have fitted all the episodes of fourteen centuries into one continuous drama of humanity, and the multitudinous historic characters that tread his vast stage in a pageant beyond the dreams of imaginative poets, though shown in true historic perspective, are all endowed with their dramatic values to the furtherance of the grandiose scheme of the arch-director, who summons them back with such a wonderful illusion of life to re-tread the stage of history. Some would say, however, that Gibbon, in an age of intellectual riches and spiritual poverty, and by reason of his temperamental lack of sympathy, forgot his customary impartiality in the famous 15th and 16th chapters, in which he explained the rise of Christianity. In spite of this, "The Decline and Fall" is one of the inevitable items in any list of books to read. Gibbon's "Memoirs" is also one of the books that should be read and re-read; it is the best autobiography in English.

The Irishman, Edmund Burke (1729–97), was a statesman and orator as well as an author. Matthew Arnold has described Burke as the greatest master of English prose style that ever lived. Apart from his speeches, Burke's principal prose works are: "A Vindication of Natural Society," written to ridicule Bolingbroke's views on society and religion; an "Inquiry into the Sublime and the Beautiful," and "Reflections on the Revolution in France."

Of all the eighteenth century writers, perhaps Burke is the one whom the student can least afford to neglect. De Quincey, who was no hasty eulogist, considered him the supreme writer of his

time. Whether that judgement can be entirely justified is not easy to show without entering into detailed comparisons between Burke and his contemporaries; but the fact remains that for much that makes for true citizenship, as well as for the literary graces, the student must have recourse to the works of Edmund Burke—his speeches not less than his writings. He helps us marvellously to a clear understanding of the public life of our country, though he may not always convince us.

We must not be content, however, with knowing Burke in "The Sublime and the Beautiful," which, though somewhat crude, is a notable contribution to aesthetics; his "Reflections on the Revolution in France," far less known to the ordinary reader, is even more worthy of study. It presents lucidly his horror of violence and his contention that liberty is only to be admired in the guise of order. His speeches present a rich field whence we may glean knowledge of life and wisdom.

Horace Walpole, fourth Earl of Orford (1717–97), set up a private press, whence he issued "A Catalogue of Royal and Noble Authors." He also wrote "Anecdotes of Painting in England"; a tragedy, "The Mysterious Mother," and a romance entitled "The Castle of Otranto." He left nearly 3,000 letters and a "History of the Last Ten Years of the Reign of George II." Walpole possessed a brilliant style, which will serve to keep his works alive and render his letters readable independently of their historical value.

Adam Smith (1723–90) wrote a work entitled "The Wealth of Nations," which originated the study of "political economy" as a distinct branch of science, inspired a world-wide interest in the sources of wealth, and was responsible for the rise of the theory of Free Trade. "The Wealth of Nations" is a book that may still be studied with pleasure and profit. It affords an example of the way in which a "dry" subject may be treated so as to appeal to the popular mind.

Our Course in English Literature is continued in Volume 5.

LESSON 29

Third Conjugation Verbs

THE so-called regular third conjugation consists of only seven verbs. With the exception of *devoir*, to owe, and its derivative *redevoir*, still to owe, all the third conjugation verbs belong to the same group. They are: *apercevoir*, to perceive; *concevoir*, to conceive; *décevoir*, to deceive; *percevoir*, to perceive (receive impressions), also to levy taxes, and *recevoir*, to receive. It is to be noted that in these verbs, the *c* takes a cedilla (*ç*) when it occurs before *o* or *u*, in order to retain the soft sound throughout the verb.

INDICATIVE MOOD.

Simple Tenses.	Compound Tenses.
Present.	*Past Indefinite.*
I receive, am receiving, etc.	I have received, etc.
je reçois	*j'ai reçu*
tu reçois	*tu as reçu*
il, elle reçoit	*il, elle a reçu*
nous recevons	*nous avons reçu*
vous recevez	*vous avez reçu*
ils, elles reçoivent	*ils, elles ont reçu*
Imperfect.	*Pluperfect.*
I was receiving, etc.	I had received, etc.
je recevais	*j'avais reçu*
tu recevais	*tu avais reçu*
il, elle recevait	*il, elle avait reçu*
nous recevions	*nous avions reçu*
vous receviez	*vous aviez reçu*
ils, elles recevaient	*ils, elles avaient reçu*
Past Definite.	*Past Anterior.*
I received, etc.	I had received, etc.
je reçus	*j'eus reçu*
tu reçus	*tu eus reçu*
il, elle, reçut	*il, elle eut reçu*
nous reçûmes	*nous eûmes reçu*
vous reçûtes	*vous eûtes reçu*
ils, elles reçurent	*ils, elles eurent reçu*

Future.
I shall receive, etc.
je recevrai
tu recevras
il, elle recevra
nous recevrons
vous recevrez
ils, elles recevront

Future Anterior.
I shall have received, etc.
j'aurai reçu
tu auras reçu
il, elle aura reçu
nous aurons reçu
vous aurez reçu
ils, elles auront reçu

CONDITIONAL.

Present.
I would receive, etc.
je recevrais
tu recevrais
il, elle recevrait
nous recevrions
vous recevriez
ils, elles recevraient

Past.
I would have received
j'aurais reçu
tu aurais reçu
il, elle aurait reçu
nous aurions reçu
vous auriez reçu
ils, elles auraient reçu

IMPERATIVE.

reçois, receive (thou)
qu'il reçoive, let him receive
qu'elle reçoive, let her receive
recevons, let us receive
recevez, receive (ye)
qu'ils reçoivent, let them (m.) receive
qu'elles reçoivent, let them (f.) receive

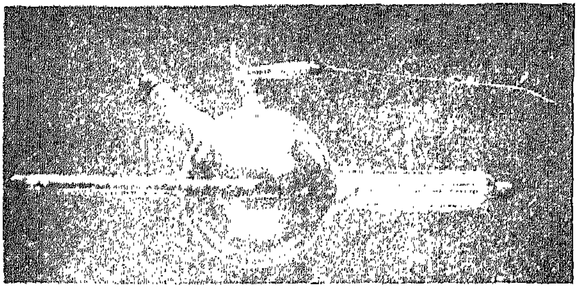
SUBJUNCTIVE.

Present.
That I may receive, etc.
que je reçoive
que tu reçoives
qu'il, qu'elle reçoive
que nous recevions
que vous receviez
qu'ils, qu'elles reçoivent

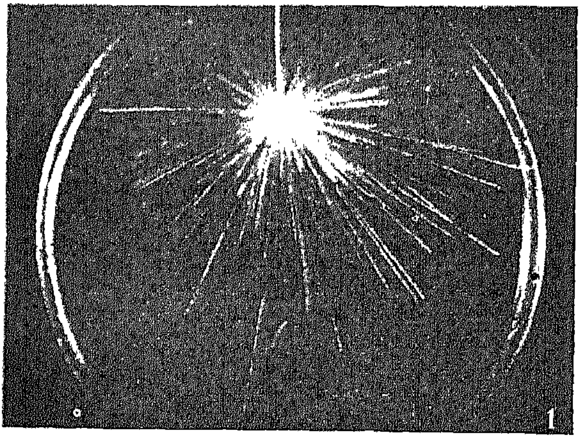
Past.
That I may have received, etc.
que j'aie reçu
que tu aies reçu
qu'il, qu'elle ait reçu
que nous ayons reçu
que vous ayez reçu
qu'ils, qu'elles aient reçu

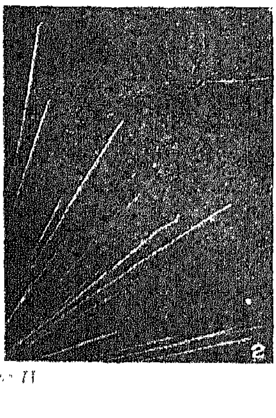
Imperfect.
That I might receive, etc.
que je reçusse
que tu reçusses
qu'il, qu'elle reçût

Pluperfect.
That I might have received, etc.
que j'eusse reçu
que tu eusses reçu
qu'il, qu'elle eût reçu

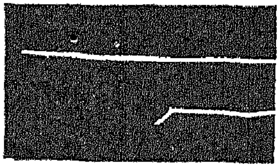


X-RAY TUBE. Fig. 3. Ordinary type of soft or "gas" tube used in hospitals, etc., in the preparation of skiagrams. CHEMISTRY 30

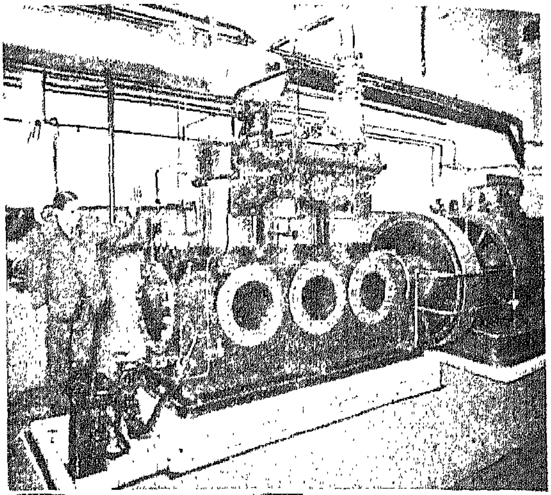


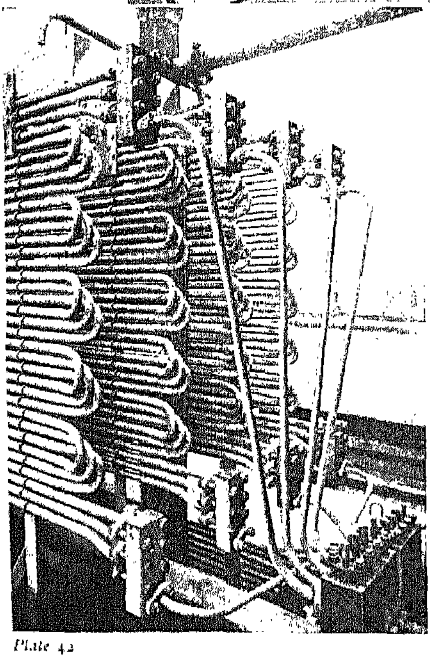


TRACKS OF ALPHA-PARTICLES. Fig. 1. Alpha rays of radium proceeding from the needle-point of a spinthariscope. **Fig. 2.** Fog tracks of alpha rays. CHEMISTRY 32



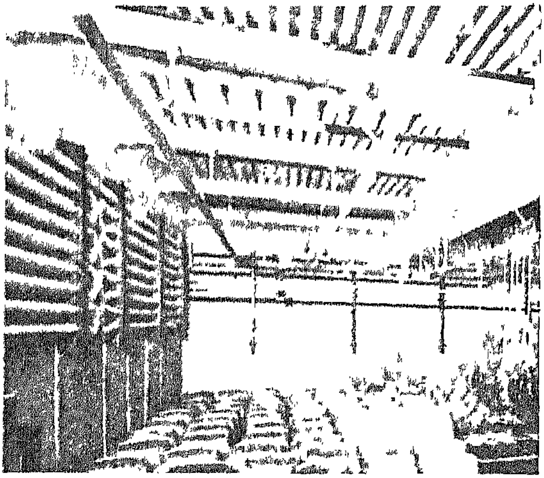
ALPHA-RAYS OF RADIUM. Above, two alpha-ray cloud tracks, an enlargement of part of the photograph on the left. CHEMISTRY 33





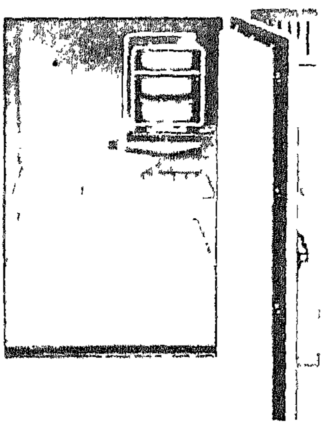
REFRIGERATION. Fig. 2 (above). Refrigerating plant comprising the latest type of quick revolution compressors direct coupled to electric motors. **Fig. 3** (left). An interlaced coil atmospheric condenser showing the gas-distributing system with headers and isolating valves.
ENGINEERING 22

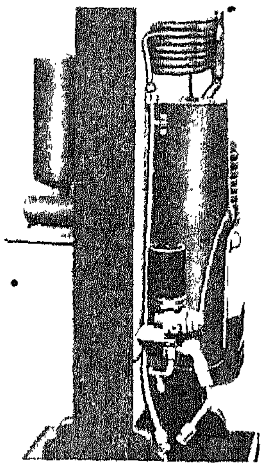
Courtesy of Messrs. J. & E. Hall, Ltd.



REFRIGERATION **Fig 2** A [illegible] example of a [illegible] refrigeration [illegible] cooled by the circulation of cold [illegible] (ENGINEERING 25)

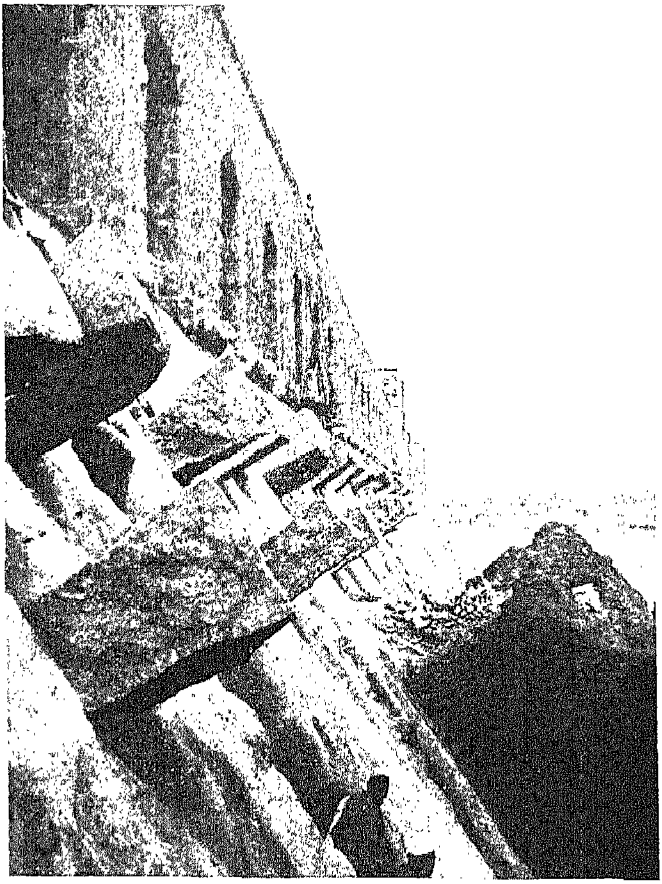
[illegible]





HOME REFRIGERATION. Fig 3. A small domestic refrigerator **Fig. 4.** Details of the cooling unit (ENGINEERING 43)

Photos courtesy of [illegible]



DAMMING THE BLUE NILE. This photograph shows the Makwar or Sennar dam, about 200 miles south-east of Khartum, that traps the flood waters from the Abyssinian highlands. The great protruding granite wedges have been provided to break the force of the tremendous fall of water that otherwise might damage the surface of the dam. The dam is 3,300 yards in length. ENGINEERING 21

Topical

que nous reçussions	*que nous eussions reçu*
que vous reçussiez	*que vous eussiez reçu*
qu'ils, qu'elles reçussent	*qu'ils, qu'elles eussent reçu*

INFINITIVE

Present.	*Past.*
recevoir, to receive	*avoir reçu*, to have received

PARTICIPLE.

Present.	*Past.*
recevant, receiving	*reçu, e*, received
	ayant reçu, having received

EXERCISE.

TRANSLATE INTO FRENCH: 1. When I was a child I was very bashful (*honteux*). 2. The earth is never ungrateful (*ingrat*); it feeds (*nourrir*) with (*de*) its fruits all those who cultivate it. 3. It is not age, it is grief (*le chagrin*) that has made his hair white (*blanchir*). 4. If you do not choose (*choisir*) a good spot (*un endroit*) to lay (*établir*) the foundation (*les fondations*) of the house, you will be obliged to pull it down (*démolir*). 5. The shame of that action reflects (*réfléchir*) on all those who have participated (*participer à*) in it. 6. Amongst the trees, almond-trees (*amandier*) blossom (the) first, and medlars (*néflier*) last. 7. After so many calamities (*calamité*) it is astonishing (*étonnant*) that this country should be (pres. subj.) so flourishing today. 8. The arms which have been blessed by (*par*) the Church are not always blessed by (*de*) heaven on the battlefield. 9. There are men by (of) whom it is glorious to be hated. 10. We (one) do not always hate those whom we render unhappy. 11. Good books cure (*guérir*) the diseases (*la maladie*) of the mind (*esprit*, m.). 12. A free (*libre*) people (*peuple*) obeys (*obéir*), but it does not serve (*sert*).

KEY TO EXERCISE IN LESSON 28.

1. Plus il avançait en âge, plus il avançait en sagesse. 2. La manière dont les Romains prononçaient le latin était très différente de celle dont nous le prononçons aujourd'hui. 3. Il partagea sa fortune entre ses trois enfants. 4. Selon un proverbe français, l'appétit vient en mangeant. 5. Il appelle sur son bienfaiteur les bénédictions du ciel. 6. On dit d'un homme qui dissipe sa fortune, qu'il jette son argent par la fenêtre. 7. Cette lettre nous annonce une bonne nouvelle. 8. La leçon commence à la page soixante-dix. 9. Envoyez cette pendule chez l'horloger pour qu'il l'arrange. 10. Je gagerais volontiers cent francs que

ce n'est pas lui qui remportera le prix 11 En mil six cent soixante, Charles II fut rappele au trône 12 Ce poisson est trop petit, rejetez-le dans l'eau 13 Quand les pêcheurs seront en pleine mer, ils jetteront leurs filets 14 Ceux qui emploient mal leur temps sont les premiers a se plaindre de sa brièveté 15 La lumière emploie de sept à huit minutes à nous venir du soleil 16 Nous pardonnons souvent à ceux qui nous ennuient, mais nous pardonnons rarement à ceux que nous ennuyons 17 Nous avons acheté la victoire au prix de nos meilleurs soldats 18 Ce qu'on achète en détail est plus cher que ce qu'on achète en gros 19 Il a gelé toute la nuit, s'il gèle encore demain, nous pourrons peut-être patiner samedi 20 Tout chemin mène à Rome, dit le proverbe

LESSON 30

Verbs of the 3rd and 4th Conjugations

Of the third conjugation, the verb *devoir* calls for special notice, as regards its conjugation, its idiomatic meanings and its uses In *devoir* the letter *d* takes the place of the *rec* of *recevoir* Consequently, its principal parts are *devoir, devant dû* (fem *due*, plur *dus*), *je dois, je dus*

When *devoir* is used in the present or the imperfect of the indicative, and followed by another verb in the infinitive, it is equivalent to the English "I am to," "I was to," "I have to" Examples *Je dois prochainement recevoir de l'argent*, I am to receive some money shortly, *il doit y avoir demain une assemblée des actionnaires*, there is to be a meeting of the shareholders tomorrow, *je dois aller demain à la campagne*, I have to go to the country tomorrow

In the present indicative it sometimes expresses what is held to be a certainty, and is then to be translated by "must", *s'il a fait vingt milles, il doit être bien fatigué*, if he has walked (lit., done) twenty miles, he must be very tired In the same tense it may also express moral obligation Example *un bon fils doit respecter son père*, a good son should respect his father

In the present conditional (*je devrais*, etc), *devoir* is to be translated by "ought"; and in the past conditional (*j'aurais dû*, etc.), by "ought to have." Example: *vous devriez lui payer*

d'abord ce que vous lui devez, you ought first of all to pay him what you owe him ; *vous n'auriez pas dû lui dire cela,* you ought not to have told him that.

In the past indefinite, and occasionally in the past definite and pluperfect (*j'ai dû, je dus, j'avais dû*), *devoir* implies obligation ; *j'ai dû lui donner quelque chose pour m'en débarrasser,* I had to give him something to get rid of him.

It is to be carefully noted that, in all these constructions, the verb following *devoir* is in the present infinitive.

EXERCISE I.

TRANSLATE INTO FRENCH : 1. We receive two papers every day. 2. She receives her friends on Thursdays (*le jeudi*). 3. We perceived a little white house at the foot of the hill. 4. Have you not yet received any reply (*réponse,* f.) to your letter ? 5. It is easy to express (*énoncer*) clearly (*clairement*) what one conceives properly (*bien*). 6. When you receive this letter I shall no longer be in England. 7. About ten o'clock in the morning we perceived the hostile (*ennemi*) army in the distance (*lointain,* m.). 8. He owes his tailor fifty francs. 9. If you owe him so much, do you owe me nothing ? 10. You ought to plant some trees along (*le long de*) that avenue (*allée,* f.). 11. When is there to be a meeting of the shareholders ? 12. If good faith (*foi,* f.) were exiled from the rest of the earth, it ought to be found again (*se retrouver*) in the heart of kings. 13. You ought first of all to pay me what you owe me. 14. She must have been greatly astonished at (*de*) seeing you.

Fourth Conjugation. As an example of verbs of the fourth conjugation we take the verb *vendre,* to sell. Principal parts : *vendre, vendant, vendu, je vends, je vendis.*

INDICATIVE MOOD.

SIMPLE TENSES.	COMPOUND TENSES.
Present.	*Past Indefinite.*
I sell, am selling, etc.	I have sold, etc.
je vends	*j'ai vendu*
tu vends	*tu as vendu*
il, elle vend	*il, elle a vendu*
nous vendons	*nous avons vendu*
vous vendez	*vous avez vendu*
ils, elles vendent	*ils, elles ont vendu*

Imperfect.	*Pluperfect.*
I was selling, used to sell, etc.	I had sold, etc.
je vendais	*j'avais vendu*
tu vendais	*tu avais vendu*
il, elle vendait	*il, elle avait vendu*
nous vendions	*nous avions vendu*
vous vendiez	*vous aviez vendu*
ils, elles vendaient	*ils, elles avaient vendu*
Past Definite.	*Past Anterior.*
I sold, etc.	I had sold, etc.
je vendis	*j'eus vendu*
tu vendis	*tu eus vendu*
il, elle vendit	*il, elle eut vendu*
nous vendîmes	*nous eûmes vendu*
vous vendîtes	*vous eûtes vendu*
ils, elles vendirent	*ils, elles eurent vendu*
Future.	*Future Anterior.*
I shall sell, etc.	I shall have sold, etc.
je vendrai	*j'aurai vendu*
tu vendras	*tu auras vendu*
il, elle vendra	*il, elle aura vendu*
nous vendrons	*nous aurons vendu*
vouz vendrez	*vous aurez vendu*
ils, elles vendront	*ils, elles auront vendu*

CONDITIONAL.

Present.	*Past.*
I would sell, etc.	I would have sold, etc
je vendrais	*j'aurais vendu*
tu vendrais	*tu aurais vendu*
il, elle vendrait	*il, elle aurait vendu*
nous vendrions	*nous aurions vendu*
vous vendriez	*vous auriez vendu*
ils, elles vendraient	*ils, elles auraient vendu*

IMPERATIVE.

vends, sell (thou)
qu'il vende, let him sell
qu'elle vende, let her sell
vendons, let us sell
vendez, sell (ye)
qu'ils, qu'elles vendent, let them sell

SUBJUNCTIVE.

Present.	*Past.*
That I may sell, etc.	That I may have sold, etc.
que je vende	*que j'aie vendu*
que tu vendes	*que tu aies vendu*
qu'il, qu'elle vende	*qu'il, qu'elle ait vendu*
que nous vendions	*que nous ayons vendu*
que vous vendiez	*que vous ayez vendu*
qu'ils, qu'elles vendent	*qu'ils, qu'elles aient vendu*
Imperfect.	*Pluperfect.*
That I might sell	That I might have sold
que je vendisse	*que j'eusse vendu*
que tu vendisses	*que tu eusses vendu*
qu'il, qu'elle vendît	*qu'il, qu'elle eût vendu*
que nous vendissions	*que nous eussions vendu*
que vous vendissiez	*que vous eussiez vendu*
qu'ils, qu'elles vendissent	*qu'ils, qu'elles eussent vendu*

INFINITIVE.

Present.	*Past.*
vendre, to sell	*avoir vendu*, to have sold

PARTICIPLE.

Present.	*Past.*
vendant, selling	*vendu, e*, sold
	ayant vendu, having sold

NOTE. The 3rd sing. pres. indic. of all verbs like *vendre* ends in *d*, except *rompre*, which has *rompt*.

The fourth conjugation verbs used in the exercise which follows are:

attendre, to wait for	*fondre*, to melt
descendre, to come down, fall	*mordre*, to bite
	perdre, to lose.
entendre, to hear, understand	*rendre*, to return, render, yield
étendre, to extend	*répondre*, to answer

EXERCISE II.

TRANSLATE INTO FRENCH: 1. Do you hear what I tell you? 2. Do not be afraid of the dog, it will not bite you. 3. You are always losing something. 4. Why have you not answered (to) his letter? 5. We heard some noise (*bruit*, m.), upstairs (*en haut*). 6. Let them wait for us now, we have waited long enough

for them 7 Wait for them, they are not ready (*prêt*) yet 8 Do not lose so much time in (*à*) chattering (*bavarder*) 9 The enemy (pl), coming down from their mountains, pillaged (*piller*) the whole district (*contree*) 10 Those houses will be sold by auction (*aux enchères*) at eleven o clock precisely 11 I closed my eyes and I heard a frightful (*epouvantable*) din (*fracas*, m) 12 You will lose nothing by (*pour*) waiting 13 The discovery of America greatly extended European commerce 14 The thermometer (*thermomètre*, m) has fallen (*de*) four degrees since yesterday 15 The young man thanked us without embarrassment for the service which we were rendering him 16 The blows (*coup* m) which we feel (*sentons*) most are those which we can (*pouvons*) not return 17 Some grains (*grain*, m) yield a hundred fold (hundred for one), others sixty, and others thirty

KEY TO EXERCISE IN LESSON 29

1 Quand j'étais enfant j'étais tres honteux 2. La terre n'est jamais ingrate elle nourrit de ses fruits tous ceux qui la cultivent 3 Ce n'est pas l age, c est le chagrin qui a blanchi ses cheveux 4 Si vous ne choisissez pas un bon endroit pour établir les fondations de la maison, vous serez oblige de la demolir 5 La honte de cette action reflechit sur tous ceux qui y ont participé 6 Parmi les arbres, les amandiers fleurissent les premiers, et les nefliers les derniers 7 Apres tant de calamites il est étonnant que ce pays soit aujourd'hui si florissant 8 Les armes qui ont été bénites par l Eglise ne sont pas toujours bénies du ciel sur le champ de bataille 9 Il y a des hommes dont il est glorieux d'être hai 10 On ne hait pas toujours ceux que l'on rend malheureux 11 Les bons livres guerissent les maladies de l'esprit 12 Un peuple libre obéit, mais il ne sert pas

LESSON 31

Pronominal Verbs

THE pronominal verbs have a pronoun *me, te, se, nous, vous,* standing as direct object (acc) or indirect object (dat) Most pronominal verbs are reflexive, that is, the object and subject both refer to the same person The student will observe that the compound tenses of the model verb below are made with *être*, this is the case with all pronominal verbs

The past participle in compound tenses follows the rule for the agreement of the past participle when compounded with *avoir*: it agrees with its direct object when that direct object precedes the verb. The following points should be also noted:

1. These verbs fall into two classes: (*a*) essentially reflexive, i.e. conjugated always with the reflexive pronoun, e.g. *se repentir*, to repent, (*b*) accidentally reflexive, i.e. verbs used either without or with the reflexive pronouns; e.g *lever*, to raise, *se lever*, to rise.

2. The pronoun object of the reflexive verb may be (*a*) direct, (*b*) indirect e.g *il se* (acc.) *lave*, he washes himself; *il se* (dat.) *lave les mains*, he washes his hands. If the reflexive pronoun is the direct object, the past participle agrees with it in gender and number, thus: *elles se sont lavées*, but, *elles se sont lavé les mains* (direct object)

3. Pronominal verbs are often used, in the plural, reciprocally, when they indicate an action which several subjects mutually do to each other, thus: *ils s'embrassèrent*, they embraced each other. Sometimes the reciprocity is not clear, thus: *ils se flattent* may mean " they flatter themselves " or " each other." To make the reciprocal use plain add *l'un l'autre, l'une l'autre, les uns les autres, les unes les autres* or *mutuellement*, or *réciproquement*, thus: *ils se flattent les uns les autres*, they flatter one another

4. For convenience, the infinitive is designated by the pronoun *se*, but any of the others may equally well be used: *Je vais me promener, il est temps de te lever*, etc.

As an example of pronominal verbs we give the conjugation scheme of *se lever*. Principal parts: *se lever, se levant, s'étant levé, je me lève, je me levai*.

INDICATIVE MOOD.

Present.	*Past Definite.*
I rise, etc.	I rose, etc.
je me lève	*je me levai*
tu te lèves	*tu te levas*
il se lève	*il se leva*
elle se lève	*elle se leva*
nous nous levons	*nous nous levâmes*
vous vous levez	*vous vous levâtes*
ils se lèvent	*ils se levèrent*

Imperfect.	*Future.*
I was rising, etc.	I shall rise, etc.
je me levais	*je me lèverai*
tu te levais	*tu te lèveras*
il se levait	*il se lèvera*
nous nous levions	*nous nous lèverons*
vous vous leviez	*vous vous lèverez*
ils se levaient	*ils se lèveront*

In all the compound tenses the past participle must agree in each case with the reflexive pronoun, which is the direct object, but such variations are noted only in the first tense.

COMPOUND TENSES.

Past Indefinite.

I have risen, etc.
je me suis levé, or *levée*
tu t'es levé, or *levée*
il s'est levé
elle s'est levée
nous nous sommes levés, or *levées*
vous vous êtes levés, or *levées*
ils se sont levés
elles se sont levées

Pluperfect.

I had risen, etc.
je m'étais levé
tu t'étais levé
il s'était levé
nous nous étions levés
vous vous étiez levés
ils s'étaient levés

Past Anterior.

I had risen, etc.
je me fus levé
tu te fus levé
il se fut levé
nous nous fûmes levés
vous vous fûtes levés
ils se furent levés

Future Anterior.

I shall have risen, etc.
je me serai levé
tu te seras levé
il se sera levé
nous nous serons levés
vous vous serez levés
ils se seront levés

CONDITIONAL

Present.

I should rise, etc.
je me lèverais
tu te lèverais
il se lèverait
nous nous lèverions
vous vous lèveriez
ils se lèveraient

Past.

I should have risen, etc.
je me serais levé
tu te serais levé
il se serait levé
nous nous serions levés e
vous vous seriez levés
ils se seraient levés

IMPERATIVE.

lève-toi, rise (thou)
qu'il se lève, let him rise
levons-nous, let us rise
levez-vous, rise ye
qu'ils se lèvent, let them (m.) rise

SUBJUNCTIVE MOOD.

Present.

That I may rise, etc.
que je me lève
que tu te lèves
qu'il se lève
que nous nous levions
que vous vous leviez
qu'ils se lèvent

Imperfect.

That I might rise, etc.
que je me levasse
que tu te levasses
qu'il se levât
que nous nous levassions
que vous vous levassiez
qu'ils se levassent

Past.

That I may have risen, etc.
que je me sois levé
que tu te sois levé
qu'il se soit levé
que nous nous soyons levés
que vous vous soyez levés
qu'ils se soient levés

Pluperfect.

That I might have risen, etc.
que je me fusse levé
que tu te fusses levé
qu'il se fût levé
que nous nous fussions levés
que vous vous fussiez levés
qu'ils se fussent levés

INFINITIVE.

Present.

se lever, to rise

Past.

s'être levé, to have risen

PARTICIPLES.

Present.

se levant, rising

Past.

s'étant levé, having risen

NOTES.—Pronominal verbs are conjugated negatively: (1) in simple tenses, by putting *ne* between the two pronouns and *pas* after the verb: *je ne me trompe pas*, I am not mistaken: (2) in

compound tenses, by putting *ne* between two pronouns, and *pas* between the auxiliary and the past participle : *je ne me suis pas trompé*, I have not been mistaken.

Contrast also in the negative imperative the position of the reflexive pronouns with that in the imperative affirmative ; *ne te trompe pas*, be (thou) not mistaken ; and in the infinitive note the positions of the *ne pas* : Present : *ne pas se tromper*, not to be mistaken ; Past : *ne pas s'être trompé* (*e*, *és*, *ées*), not to have been mistaken.

KEYS TO EXERCISES IN LESSON 30.

(I) 1. Nous recevons deux journaux tous les jours. 2. Elle reçoit ses amis le jeudi. 3. Nous aperçûmes une petite maison blanche au pied de la colline. 4. N'avez-vous pas encore reçu de réponse à votre lettre ? 5. Il est facile d'énoncer clairement ce que l'on conçoit bien. 6. Quand vous recevrez cette lettre je ne serai plus en Angleterre. 7. Vers dix heures du matin nous aperçûmes l'armée ennemie dans le lointain. 8. Il doit cinquante francs à son tailleur. 9. Si vous lui devez tant, ne me devez-vous rien ? 10. Vous devriez planter des arbres le long de cette allée. 11. Quand doit-il y avoir une assemblée des actionnaires ? 12. Si la bonne foi était exilée du reste de la terre, elle devrait se retrouver dans le cœur des rois. 13. Vous devriez d'abord me payer ce que vous me devez. 14. Elle a dû être bien étonnée de vous voir.

(II) 1. Entendez-vous ce que je vous dis ? 2. N'ayez pas peur du chien ; il ne vous mordra pas. 3. Vous perdez toujours quelque chose. 4. Pourquoi n'avez-vous pas répondu à sa lettre ? 5. Nous entendîmes du bruit en haut. 6. Qu'ils nous attendent maintenant, nous les avons attendus assez longtemps. 7. Attendez les ; ils ne sont pas encore prêts. 8. Ne perdez pas tant de temps à bavarder. 9. Les ennemis, descendant de leurs montagnes, pillaient toute la contrée. 10. On vendra ces maisons aux enchères à onze heures précises. 11. Je fermai les yeux et j'entendis un fracas épouvantable. 12. Vous ne perdrez rien pour attendre. 13. La découverte de l'Amérique a beaucoup étendu le commerce européen. 14. Le thermomètre a descendu de quatre degrés depuis hier. 15. Le jeune homme nous remercia sans embarras du service que nous lui rendions. 16. Les coups que nous sentons le plus sont ceux que nous ne pouvons (pas) rendre. 17. Quelques grains rendent cent pour un, d'autres soixante, et d'autres trente.

LESSON 32

Passive and Neuter Verbs

PRONOMINAL verbs are conjugated interrogatively, in simple tenses, by putting the pronoun subject after the verb, and in compound tenses after the auxiliary verb. These verbs may, like all other verbs, be conjugated interrogatively by prefixing *est-ce que* without inversion. This form is most commonly used in the case of the first person singular of the simple tenses: thus, *se flatter*, to flatter oneself, conjugated interrogatively, has indicative present, *est-ce que je me flatte ? nous flattons-nous ?* Imperfect, *est-ce que je me flattais ? nous flattions-nous ?* In compound tenses the construction is: past indefinite (have I flattered myself ?), *me suis-je flatté*, or *flattée ? nous sommes-nous flattés*, or *flattées ?* etc.

When conjugating pronominal verbs interrogatively and negatively, taking the verb *s'apercevoir*, to perceive, as an example, the construction of the indic. pres. is: *est-ce que je ne m'aperçois pas ? ne nous apercevons nous pas ?* and in the compound tenses: past indef., *ne me suis-je pas aperçu*, or *aperçue ? ne nous sommes-nous pas aperçus*, or *aperçues*.

Of the pronominal verbs that have the second pronoun for their direct object, some take the preposition *à*, others the preposition *de*, before their indirect object. These prepositions are indicated in this list of verbs that occur in the exercise which follows it.

s'aider, to help oneself
s'apercevoir de, to perceive
s'appeler, to be called
s'arrêter, to stop
se battre, to fight
se défendre, to defend oneself
se défier de, to distrust
se déguiser, to disguise oneself
se dévouer, to devote oneself
s'ennuyer de, to weary of
s'emparer de, to take possession of, to seize
se glorifier de, to be proud of
se méfier de, to mistrust
se mettre à, to set about, to begin
se plaire à, to take pleasure in
se ralentir, to slacken
se trouver, to find oneself, to happen to be
se vanter de, to boast of

EXERCISE.

TRANSLATE INTO FRENCH: 1. It seems to me that I have already seen that lady. What is her name? (How does she call herself?) 2. The vanquished (*vaincu*) have not fought less well than the victors (*vainqueur*). 3. The enemy (singular) have taken possession of the town, after a long siege, during which the inhabitants defended themselves as courageously (*courageusement*) as the soldiers. 4. We distrust others too much, and we do not mistrust ourselves sufficiently. 5. There are men who are prouder (glorify themselves more) of their defects (*le défaut*) than of their good qualities. 6. "Help thyself, heaven will help thee," says the proverb. 7. They (f.) perceived their error, but it was too late. 8. A writer (*écrivain*) has said that if we often boast of not wearying, it is because we are so conceited (*glorieux*) that we do not wish (*voulons*) to consider (find) ourselves (*de*) bad company (*la campagnie*). 9 At what time do you usually (*ordinairement*) get up? We usually get up at half-past seven, and we rarely go to bed before half-past eleven. 10. Great motives may (*peuvent*) induce (*engager*) us to humble (*humilier*) ourselves, none to demean (*avilir*) ourselves. 11. The Romans, after having taken possession of Gaul (*la Gaule*), gave it in a short time their civilization. 12. It is (*vaut*) better to expose oneself to ingratitude than to leave a wretched (man) (*malheureux*) without help (*secours*). 13. History tells us that there have been kings who devoted (*dévouer*) themselves to death for the safety (*le salut*) of their people. 14. There is a great deal of difference between (*entre*) taking pleasure (*se plaire*) in a (*à*) work and being suited (*propre*) for (to) it. 15. We are so accustomed (*accoutumés*) to disguise ourselves to others, that in the end (*enfin*) we disguise ourselves to ourselves. 16. It is as easy to deceive (*tromper*) oneself without perceiving it, as it is difficult to deceive others without their (that they) perceiving it.

Passive Verbs. Verbs in the passive voice, or passive verbs, as they are commonly called (*verbes passifs*), consist of the past participle of an active verb added to the verb *être*, to be. Thus, *aimer*, to love; *être aimé*, to be loved; *j'aime*, I love; *je suis aimé*, I am loved; *La mère a grondé l'enfant*, The mother has scolded the child; *L'enfant a été grondé par sa mère*, The child has been scolded by his mother.

In passive verbs, the past participle always agrees with the subject: *Jeanne d'Arc fut brûlée sur la place publique de Rouen*,

Joan of Arc was burnt in the public square at Rouen. The passive voice presents no difficulty It will suffice to give one simple tense and one compound tense as models :

INDICATIVE MOOD.

Present

je suis aimé, or *aimée*, I am loved, etc.
tu es aimé, or *aimée*
il est aimé, elle est aimée
nous sommes aimés, or *aimées*
vous êtes aimé or *aimé, aimés* or *aimées*
ils sont aimés, elles sont aimées

Past Indefinite

j'ai été aimé, or *aimée*, I have been loved, etc.
tu as été aimé, or *aimée*
il a été aimé, elle a été aimée
nous avons été aimés, or *aimées*
vous avez été aimé or *aimée, aimés* or *aimées*
ils ont été aimés, elles ont été aimées

The subject of a verb in the passive voice can only be that which would be the direct object or accusative of the same verb in the active voice. The indirect object or dative of the active may never be the subject of the passive voice Thus, the verb *dire*, to tell, requires the indirect object : *je lui dis*, I tell (to) him.

The passive construction is used far less frequently in French than it is in English. In the former language it is very commonly rendered by an active construction with *on* as subject, or by means of a reflexive verb : It is said that the enemy have taken possession of the town, *On dit que l'ennemi s'est emparé de la ville ;* That word is not found in the dictionary, *Ce mot ne se trouve pas dans le dictionnaire.*

Neuter Verbs. The neuter, or intransitive, verb (*verbe neutre ou intransitif*) is that which can never have a direct object or accusative, and which, consequently, has no passive voice. Some neuter verbs are conjugated with *être* as their auxiliary in the compound tenses. The more common of these are :

aller, to go	*partir*, to go away
arriver, to arrive	*rester*, to remain
entrer, to enter	*sortir*, to go out
mourir, to die	*tomber*, to fall
naître, to be born	*venir*, to come, and some of its derivatives.

LESSON 33

Impersonal Verbs

IMPERSONAL or unipersonal verbs (*verbs impersonnels ou unipersonnels*) are intransitive verbs used only in the third person singular, or in the infinitive and participles. *Il est* is used to form impersonal expressions: *il est vrai que je suis son ami*, it is true I am his friend. *Avoir*, preceded by *y*, is used impersonally, with the meaning of "to be": *il y a un Dieu*, there is a God. *Faire*, to make, is used impersonally, with the meaning of "to be," in a number of expressions chiefly referring to the state of the weather: *il fait beau*, it is fine; *il fait mauvais temps*, it is bad weather; *il fait froid*, it is cold.

The following verbs are always impersonal:

INFINITIVE.	INDICATIVE PRESENT.
pleuvoir, to rain	*il pleut*, it rains
neiger, to snow	*il neige*, it snows
grêler, to hail	*il grêle*, it hails
tonner, to thunder	*il tonne*, it thunders
geler, to freeze	*il gèle*, it freezes
dégeler, to thaw	*il dégèle*, it thaws
bruiner, to drizzle	*il bruine*, it drizzles
venter, to be windy	*il vente*, it is windy
importer, to matter	*il importe*, it matters
falloir, to be necessary	*il faut*, it is necessary

There are a great many verbs which are often used impersonally. Of these, the following occur most frequently:

INFINITIVE.	INDICATIVE PRESENT.
sembler, to seem	*il semble*, it seems
paraître, to appear	*il paraît*, it appears
convenir, to be suitable	*il convient*, it is suitable
arriver, to happen	*il arrive*, it happens
s'agir de, to be the question	*il s'agit de*, the question is
se trouver, to be found	*il se trouve*, it is found

The Verb Pleuvoir. The principal parts of this verb are: *pleuvoir, pleuvant, plu, il pleut, il plut.* The following is the scheme of conjugation:

IMPERSONAL VERBS

INDICATIVE MOOD.

Simple Tenses.	*Compound Tenses*
il pleut, it rains	*il a plu*, it has rained
il pleuvait, it was raining	*il avait plu*, it had rained
il plut, it rained	*il eut plu*, it had rained
il pleuvra, it will rain	*il aura plu*, it will have rained

CONDITIONAL.

il pleuvrait, it would rain	*il aurait plu*, it would have rained

SUBJUNCTIVE.

qu'il pleuve	*qu'il ait plu*
qu'il plût	*qu'il eût plu*

Uses of Falloir. *Falloir*, to be necessary, is frequently equivalent to the English verb " must." In that case the subject of " must " becomes the subject of the following verb, which requires to be in the subjunctive : *Il faut que je réponde à sa lettre*, I must answer his letter. The principal parts are: *falloir* (no pres. part.), *fallu, il faut, il fallut.*

When the statement made is general, or when the person on whom the obligation falls is sufficiently indicated by the context, the second verb may be in the infinitive . *il faut obéir aux lois*, we must obey the laws ; *mes enfants, il faut vous coucher*, children, you must go to bed.

With the infinitive construction, the person indicated by the subject of " must " may be indicated by an indirect object, or dative : *il me faut sortir*, I must go out.

In the past and future, *falloir* may be rendered by the suitable tenses of " to have to." *Il faudra nous dépêcher*, we shall have to make haste. When *falloir* is followed by a noun, it means " to want," " to require." In that case, the subject of the English verb is expressed by an indirect object, or dative, and is placed before *falloir*, if it be a personal or relative pronoun, but after it if it be a noun : *il me faut d'autres livres*, I require other books ; *il faut une nouvelle robe à ma soeur*, my sister requires a new dress.

Falloir is used idiomatically in the following expressions : (*a*) *S'en falloir de beaucoup*, to be far from ; *il s'en faut de beaucoup que la somme y soit*, the sum is far from being complete (lit., from being there). (*b*) *S'en falloir de peu* or *peu s'en falloir*, not to be far from, to want but little, to be near. *Peu s'en fallut qu'il n'en mourût*, he was near dying of it. (*c*) *Tant s'en faut*,

so far from, far from it, by a long way. *Tant s'en faut qu'il consente, qu'au contraire il fera tout pour l'empêcher*, he is so far from consenting, that, on the contrary, he will do everything to prevent it.

Comme il faut is used as a qualificative, with the meaning of "respectable," "gentlemanly," "ladylike"; and also as an adverbial phrase signifying "suitably," "properly": *C'est un homme tout à fait comme il faut*, he is quite a gentleman. *Elle a l'air très comme il faut*, she looks very ladylike.

INDICATIVE MOOD.

Simple Tenses	*Compound Tenses.*
il faut, it is necessary	*il a fallu*, it has been necessary
il fallait	*il avait fallu*
il fallut	*il eut fallu*
il faudra	*il aura fallu*

CONDITIONAL.

il faudrait	*il aurait fallu*

SUBJUNCTIVE.

qu'il faille	*qu'il ait fallu*
qu'il fallût	*qu'il eût fallu*

EXERCISE.

TRANSLATE INTO FRENCH: 1. The earth is warmed (*échauffer*) by the sun. 2. The egoist (*égoïste*) is loved by (*de*) nobody. 3. Figures (*le cheffre*) were invented (*inventer*) by the Arabs (*Arabe*). 4. The woman was deceived by the serpent (*le serpent*). 5. Thunderstorms (*un orage*) are foreseen (*prévu*) and announced by swallows. 6. America (*l'Amérique*) was discovered (*découverte*) by Christopher Columbus (*Christophe Colomb*) in 1492. 7. Printing (*l'imprimerie*, f.) was invented by Gutenberg in the fifteenth century. 8. The Cape of Good Hope (*le cap de Bonne-Espérance*) was doubled (*doubler*) for the first time by the Portuguese (*Portugais*). 9. When did you come back from Paris? 10. What day did your friends leave (*partis*) for London? 11. Since the comet (*la comète*) has (is) appeared (*apparue*) a crowd (*la foule*) of people pass the night (*à*) looking at it. 12. When we arrived at the station (*la gare*) the train (*le train*) had already started. 13. It seems that the sun turns (*tourner*)

around (*autour de*) the earth, when, on the contrary (*au contraire*) it is certain that it is the latter which turns around the sun. 14. If it freezes (in) the morning, it is often fine all day (*journée* f.). 15. A door must be open (*ouverte*) or closed, says a French proverb. 16. I have told you everything. What (of) more do you want? 17. That is just what I require; thanks (*merci*). 18. His friends are very respectable people. 19. He was very near being killed (*tuer*). 20. To (*pour*) speak well, it is necessary to say what is required, all that is required, nothing but (*rien que*) what is required, and to say it suitably

KEY TO EXERCISE IN LESSON 32.

1. Il me semble que j'ai déjà vu cette dame. Comment s'appelle-t-elle? 2. Les vaincus ne se sont pas moins bien battus que les vainqueurs 3. L'ennemi s'est emparé de la ville après un long siège, pendant lequel les habitants se sont défendus aussi courageusement que les soldats 4. Nous nous défions trop des autres, et nous ne nous méfions pas assez de nous-mêmes. 5. Il y a des hommes qui se glorifient plus de leurs défauts que de leurs bonnes qualités 6. Aide-toi, le ciel t'aidera, dit le proverbe. 7. Elles sont aperçues de leur erreur, mais il était prop tard. 8. Un écrivain a dit que si nous nous vantons souvent de ne point nous ennuyer, c'est parce que nous sommes si glorieux que nous ne voulons pas nous trouver de mauvaise compagnie. 9. A quelle heure vous levez-vous ordinairement? Nous nous levons ordinairement à sept heures, at nous nous couchons rarement avant onze heures et demie. 10. De grands motifs peuvent nous engager à nous humilier, aucun à nous avilir. 11. Les Romains, après s'être emparés de la Gaule, lui donnèrent en peu de temps leur civilisation. 12. Il vaut mieux s'exposer à l'ingratitude que de laisser sans secours un malheureux. 13. L'histoire nous dit qu'il y a eu des rois que se sont dévoués à la mort pour le salut de leur peuple. 14. Il y a bien de la différence entre se plaire à un travail et y être propre. 15. Nous sommes si accoutumés à nous déguiser aux autres, qu'enfin nous nous déguisons à nous-mêmes. 16. Il est aussi facile de se tromper soi-même sans s'en apercevoir, qu'il est difficile de tromper les autres sans qu'ils s'en aperçoivent.

LESSON 34

Some Irregular Verbs

No knowledge of the French language can be complete without a full acquaintance with the verbs classed as irregular. Amongst these there are some of which all the tenses are formed quite regularly from the principal parts, but in which these principal parts themselves present some peculiarities. As regards these verbs, it will be sufficient to give the principal parts, together with the three persons singular of the present indicative. No such verbs occur in the first conjugation, and the third has only two.

Second Conjugation. 1 ASSAILLIR, to assail, *assaillant, assailli, j'assaille, tu assailles, il assaille, j'assaillis*. Similarly *tressaillir,* to start, shudder.

2. BOUILLIR, to boil, *bouillant, bouilli, je bous, tu bous, il bout, je bouillis.* This verb is intransitive, and, consequently, its use is practically limited to the third person. "To boil" as a transitive verb is *faire bouillir,* "to make boil."

3. COUVRIR, to cover, *couvrant, couvert, je couvre, tu couvres, il couvre, je couvris.*

4. OUVRIR, to open, *ouvrant, ouvert, j'ouvre, tu ouvres, il ouvre, j'ouvris.*

5. OFFRIR, to offer, *offrant, offert, j'offre, tu offres, il offre, j'offris.*

6. SOUFFRIR, to suffer, *souffrant, souffert, je souffre, tu souffres, il souffre, je souffris.*

7. DORMIR, to sleep, *dormant, dormi, je dors, tu dors, il dort, je dormis.*

8. MENTIR, to tell a lie, *mentant, menti, je mens, tu mens, il ment, je mentis.*

9. PARTIR, to set out, *partant, parti, je pars, tu pars, il part, je partis.*

10. SENTIR, to feel, to smell, *sentant, senti, je sens, tu sens, il sent, je sentis.* Similarly *se repentir,* to repent.

11 SERVIR, to serve, *servant, servi, je sers, tu sers, il sert, je servis.*

12. SORTIR, to go out, *sortant, sorti, je sors, tu sors, il sort, je sortis.*

13. FUIR, to flee, *fuyant, fui, je fuis, tu fuis, il fuit, je fuis.*

14. VÊTIR, to clothe, *vêtant, vêtu, je vêts, tu vêts, il vêt, je vêtis.*

Third Conjugation. 1. POURVOIR, to provide, *pourvoyant, pourvu, je pourvois, tu pourvois, il pourvoit, je pourvus.*

2. PRÉVOIR, to foresee, *prévoyant, prévu, je prévois, tu prévois, il prévoit, je prévis.*

EXERCISE.

TRANSLATE INTO FRENCH: 1. Our brigade will attack (*assaillir*) the enemy in his retrenchments (*le retranchement*) tomorrow morning. 2. A few shots (*coups de feu*) are fired (go off); at this noise Napoleon starts. The Russian (*de Russie*) campaign (*la campagne*) is opened. 3. Everybody (*tout le monde*) knows (*sait*) that it was Christopher Columbus who discovered America. 4. He never opens his mouth without saying some foolish thing (*la sottise*). 5. The noise that was made (*se faisait*) in the meeting (*une assemblée*) covered the voice of the speaker (*orateur*) 6. It is certain that the sea formerly covered a great part of the inhabited (*habiter*) earth. 7. The water would boil more quickly if you lighted (*allumer*) a good fire. 8. Francis (*François*) I slept on a gun-carriage (*un affut*) the night of the battle (*la bataille*) of Marignano (*Marignan*). 9. We fall asleep (*s'endormir*) every evening whilst he reads (*lit*) the paper (*le journal*) to us. 10. When we were young we used to sleep twelve hours without awakening (*se réveiller*). 11. Isaac having asked his father where the victim (*la victime*) was which was to be sacrificed (*immoler*), Abraham answered: "God will provide for (to) it." 12. Charles the Bold (*Téméraire*) perished (*périr*) before Nancy, betrayed (*trahir*) by a Neapolitan mercenary (*un mercénaire napolitain*) and killed whilst (*en*) fleeing after the battle by a gentleman of Lorraine (*gentilhomme lorrain*). 13. Let us flee together to the depths (*le fond*) of the forests; it is better to trust (*se fier*) to tigers than to men. 14. There are people (*gens*) who lie simply for the sake of (*pour*) lying. 15. Satire (*la satire*) lies about (*on*) men of letters (*gens de lettres*) during their life, and praise (*l'éloge*) lies after their death. 16. He has been offered a situation (*une place*) in Paris, but he does not wish (*désirer*) to leave (*quitter*) London. 17. It is useful for (to) the proud (*le superbe*) to fall, because their fall opens their eyes. 18. We (*on*)

are usually (*ordinairement*) less grieved (*fâché*) when we go away than when we see (*voit*) (others) go away 19 We ought to have started for the country yesterday, but we shall start tomorrow only 20 When you (sing) tell a lie, does not your conscience (*la conscience*) reproach (*reprocher*) you (with) something, and do you not repent immediately ? 21 The judge who is faithful to his duty (*le devoir*) feels neither regrets (*le regret*) nor anger (*courroux*, m) 22 There are people who seem to think (*croire*) that the happiness of serving them is a sufficiently (*assez*) high reward (*la récompense*) for those who serve them 23 Go out when you like (*voudrez*), but I warn you (*avertir*) that I shall go out only after you (shall) have (be) gone out 24 Is it worth while (*la peine*) to live (*vivre*) when we (one) suffer ? Yes, for we always hope that we shall not suffer tomorrow 25 The misfortune (*le malheur*) of those people who know all (it) is that they never foresee anything.

KEY TO EXERCISE IN LESSON 33

1 La terre est échauffée par le soleil 2. L'égoïste n'est aimé de personne 3 Les chiffres ont été inventés par les Arabes 4 La femme fut trompee par le serpent 5 Les orages sont prévus et annoncés par les hirondelles. 6. L'Amérique fut découverte par Christophe Colomb en mil quatre cent quatre-vingt-douze. 7 L'imprimerie fut inventee par Gutenberg dans le quinzième siècle. 8. Le cap de Bonne-Espérance fut doublé pour la première fois par les Portugais 9 Quand êtes-vous revenu de Paris ? 10. Quel jour vos amis sont-ils partis pour Londres ? 11. Depuis que la comète est apparue une foule de gens passent la nuit à la regarder 12 Quand nous sommes arrivés à la gare le train était dejà parti 13. Il semble que le soleil tourne autour de la terre, quand, au contraire, il est certain que c'est celle-ci qui tourne autour du soleil 14 S'il gèle le matin, il fait souvent beau toute la journée 15 Il faut qu'une porte soit ouverte ou fermée, dit un proverbe français 16 Je vous ai tout dit Que vous faut-il de plus ? 17 C'est justement ce qu'il me faut, merci. 18. Ses amis sont des gens très comme il faut 19 Il s'en est fallu de bien peu qu'il ne fût tué 20 Pour bien parler, il faut dire ce qu'il faut, tout ce qu'il faut, rien que ce qu'il faut, et le dire comme il faut

LESSON 35

Some More Irregular Verbs

In this Lesson we continue the irregular verbs, giving the principal parts, together with the three persons singular of the present indicative of those verbs occurring in the fourth conjugation of which the tenses are formed regularly from the principal parts, though these themselves are irregular. There are twenty-four such verbs in the fourth conjugation in common use.

1. BATTRE, to beat, *battant, battu, je bats, tu bats, il bat, je battis*. The verbs conjugated like *battre* are *abattre*, to knock down, fell; *se battre*, to fight; *combattre*, to combat, *débattre*, to debate; *se débattre*, to struggle; *rabattre*, to pull down, to lower (the price)

2. CONCLURE, to conclude, *concluant, conclu, je conclus, tu conclus, il conclut, je conclus*

3. CONDUIRE, to lead, *conduisant, conduit, je conduis, tu conduis, il conduit, je conduisis* Similarly, *construire*, to construct; *cuire*, to cook, bake, *instruire*, to instruct, *réduire*, to reduce; and *traduire*, to translate

4 CONNAÎTRE, to know, to be acquainted with, *connaissant, connu, je connais, tu connais, il connaît, je connus*. The "*i*" of the stem retains the circumflex accent wherever it is followed by "*t*." Similarly, *paraître*, to appear, seem; *apparaître*, to appear; *comparaître*, to appear (before a tribunal, etc.); *disparaître*, to disappear; *reparaître*, to reappear; *reconnaître*, to recognize

5. CONFIRE, to pickle, preserve, *confisant, confit, je confis, tu confis, il confit, je confis*.

6. COUDRE, to sew, *cousant, cousu, je couds, tu couds, il coud, je cousis*

7. CROIRE, to believe, *croyant, cru, je crois, tu crois, il croit, je crus*.

8. CROÎTRE, to grow, *croissant, crû, je croîs, tu croîs, il croît, je crûs*. In this verb there is a circumflex accent not only over "*i*" when it is followed by "*t*," but over "*i*" and "*u*" in all the forms that would otherwise be identical with those of *croire*.

9. ÉCRIRE, to write, *écrivant, écrit, j'écris, tu écris, il écrit, j'écrivis.* Similarly, *décrire*, to describe; *inscrire*, to inscribe; *proscrire*, to proscribe; *souscrire*, to subscribe; and *transcrire*, to transcribe.

10. JOINDRE, to join, *joignant, joint, je joins, tu joins, il joint, je joignis.* All verbs ending in *aindre, eindre,* or *oindre*, are conjugated like this: *contraindre*, to constrain; *ceindre*, to gird; *feindre*, to feign; *atteindre*, to reach; *teindre*, to dye; *enfreindre*, to infringe; *peindre*, to paint; *rejoindre*, overtake; *oindre*, to anoint; and the reflexive verb *se plaindre*, to complain.

11. LIRE, to read, *lisant, lu, je lis, tu lis, il lit, je lus.*

12. METTRE, to put, put on, *mettant, mis, je mets, tu mets, il met, je mis,* and derivatives. Amongst them are: *admettre*, to admit; *commettre*, to commit; *compromettre*, to compromise; *omettre*, to omit; *permettre*, to allow; *promettre*, to promise; *soumettre*, to submit.

13. MOUDRE, to grind, *moulant, moulu, je mouds, tu mouds, il moud, je moulus.*

14. NAÎTRE, to be born, *naissant, né, je nais, tu nais, il naît, je naquis,* compounded with *être.*

15. NUIRE, to injure, *nuisant, nui, je nuis, tu nuis, il nuit, (je nuisis).* Similarly, *luire*, to shine; neither of these verbs has past definite.

16. PLAIRE, to please, *plaisant, plu, je plais, tu plais, il plaît* (with circumflex accent), *je plus.* Similarly, *complaire*, to gratify; *déplaire*, to displease; *se plaire à*, to delight in; *taire*, to conceal, hush up; and *se taire*, to be silent.

17. PRENDRE, to take, *prenant, pris, je prends, tu prends, il prend, nous prenons, ils prennent, je pris.* This verb doubles the "*n*" before the endings *e, es, ent.* Similarly *apprendre*, to learn; *comprendre*, to understand; *entreprendre*, to undertake; *surprendre*, to surprise.

18. REPAÎTRE, to feed, to feast, is derived from *paître*, to graze; *repaissant, repu, je repais, tu repais, il repaît, je repus.* This verb is also used reflexively: *se repaître*, and chiefly figuratively.

19. RÉSOUDRE, to resolve, solve, *résolvant, résolu, je résous, tu résous, il résout, je résolus.* This verb also means to dissolve from one substance to another, and then has *résous, résoute,* for its past participle. *Absoudre*, to absolve, and *dissoudre*, to dissolve, are conjugated in the same way; but their respective past participles are *absous*, m. *absoute*, f., and *dissous* m., *dissoute*, f.

Absolu and *dissolu* are adjectives meaning absolute and dissolute.

20. RIRE, to laugh, *riant, ri, je ris, tu ris, il rit, je ris.* *Sourire*, to smile, follows the same conjugation.

21. SUFFIRE, to suffice, *suffisant, suffi, je suffis, tu suffis, il suffit, je suffis.*

22. SUIVRE, to follow, *suivant, suivi, je suis, tu suis, il suit, je suivis.*

23. VAINCRE, to overcome, *vainquant, vaincu, je vaincs, tu vaincs, il vainc, je vainquis.* Similarly, *convaincre*, to convince.

24. VIVRE, to live, *vivant, vécu, je vis, tu vis, il vit, je vécus.* Similarly, *revivre*, to revive, and *survivre*, to survive.

EXERCISE.

TRANSLATE INTO FRENCH: 1. When the ancients besieged (*assiéger*) a town they battered (beat) the walls with (*à coups de*) ram(s) (*le bélier*). 2. One is never beaten without being struck (*frapper*); but one may (*peut*) be struck without being beaten. 3. The muleteer (*muletier*) who served us as (*de*) guide, beat his mules in a frightful (*épouvantable*) way (*la façon*). 4. We have concluded nothing, but that is not my fault. 5. He is an author whose works (*ouvrage*, m.) have been translated into all languages (*la langue*). 6. According to a distinguished writer (*écrivain*), if you always translate, you will never be translated; and yet (*cependant*) another writer, just (*tout*) as distinguished, has said that if you wish (*voulez*) to be translated (that one translate, *subj.*) some (*un*) day, you must yourself begin by translating. 7. I have seen him only once, but I should know him amongst (a) thousand. 8. That young girl sews, sings, reads; that is all she needs to be happy. 9. Who is it that used to say that, wherever (*partout où*) the lion's skin did not suffice, the fox's (*renard*) skin was to be sewn to it—that is to say, cunning (*la ruse*) to be joined to strength (*la force*)? 10. There are people who account the rest (*le reste*) of men as (*pour*) nothing, and think (believe) they are (to be) born only for themselves. 11. An honourable (*honnête*) man who says yes and no deserves (*mériter*) to be believed; his character (*le caractère*) swears for him. 12. Any (*tout*) author whom one is obliged to read twice to understand (*entendre*) him, writes badly. 13. What is written is written means (*veut dire*) that one can change nothing in (*à*) what is written. 14. It is admitted by all civilized (*civiliser*) peoples that the person of an ambassador is inviolable and sacred;

15. You depict (paint) the charms (*le charme*) of country (*champêtre*) life so well to us that you make us feel inclined to (*donner l'envie de*) go (and) live (*habiter*) in a (*au*) village. 16. The Gauls (*Gaulois*) used to transmit (the) news (*les nouvelles*) to each other by (*en*) lighting fires on the heights (*la hauteur*). 17. The days lengthen (grow) from the 21st of December to the 21st of June, they draw in (*décroître*) from the 21st of June to the 21st of December. 18. Men are like the flowers which appear and disappear with an incredible (*incroyable*) rapidity (*la rapidité*). 19. On the 11th of November, 1572, a new star appeared suddenly (*tout à coup*) in the sky, where it shone (*briller*) with (*de*) the most vivid (*vif*) brilliancy (*éclat*, m.); it disappeared in the month of May, 1574, after having lasted 16 months.

Key to Exercise in Lesson 34.

1. Notre brigade assaillira l'ennemi dans ses retranchements demain matin. 2. Quelques coups de feu partent; à ce bruit Napoléon tressaille; la campagne de Russie est ouverte. 3. Tout le monde sait que c'est Christophe Colomb qui a découvert l'Amérique. 4. Il n'ouvre jamais la bouche sans dire quelque sottise. 5. Le bruit qui se faisait dans l'assemblée couvrait la voix de l'orateur. 6. Il est certain que la mer a autrefois couvert une grande partie de la terre habitée. 7. L'eau bouillirait plus vite si vous allumiez un bon feu. 8. François premier dormit sur un affût la nuit de la bataille de Marignan. 9. Nous nous endormons tous les soirs pendant qu'il nous lit le journal. 10. Lorsque nous étions jeunes nous dormions douze heures sans nous réveiller. 11. Isaac ayant demandé à son père où était la victime qui devait être immolée, Abraham répondit: "Dieu y pourvoira." 12. Charles le Téméraire périt devant Nancy, trahi par un mercénaire napolitain, et tué en fuyant après la bataille, par un gentilhomme lorrain. 13. Fuyons ensemble au fond des forêts; il vaut mieux se fier aux tigres qu'aux hommes. 14. Il y a des gens qui mentent simplement pour mentir. 15. La satire ment sur les gens de lettres pendant leur vie, et l'éloge ment après leur mort. 16. On lui a offert une place à Paris, mais il ne désire pas quitter Londres. 17. Il est utile aux superbes de tomber, parce que leur chute leur ouvre les yeux. 18. On est ordinairement moins fâché quand on part que quand on voit partir. 19. Nous aurions dû partir pour la campagne hier, mais nous ne partirons que demain. 20. Quand tu mens,

la conscience ne te reproche-t-elle pas quelque chose, et ne te repens-tu pas aussitôt ? 21. Le juge qui est fidèle à son devoir ne sent ni regrets ni courroux. 22. Il y a des gens qui semblent croire que le bonheur de les servir est une assez haute récompense pour ceux qui les servent. 23. Sortez quand vous voudrez, mais je vous avertis que je ne sortirai qu'après que vous serez sortis. 24. Est-ce la peine de vivre quand on souffre ? Oui, car on espère toujours qu'on ne souffrira pas demain. 25. Le malheur de ces gens qui savent tout, c'est qu'ils ne prévoient jamais rien.

LESSON 36

First Conjugation Irregular Verbs

HERE we give the irregular verbs of the first conjugation in which irregularities arise in the tenses as well as in the principal parts. In all verbs the endings of the imperfect indicative, of the past definite, of the future, of the present conditional, and of the imperfect subjunctive, are regular, whatever peculiarities there may be in the stem. Consequently, only the first person singular of those tenses will be indicated. Except in special cases, the imperative will not be given, as its first and second persons are identical with the corresponding persons of the present indicative (except that the final *s* is dropped from the second person singular), and its third persons borrowed from the present subjunctive.

1. ALLER, to go, *allant*, *allé*.
Ind. Pres. : *je vais, tu vas, il va, nous allons, vous allez, ils vont.*
Imperf. : *j'allais.*
Future : *j'irai.*
Past Def. : *j'allai.*
Cond. Pres. : *j'irais.*
Imperative : *va, qu'il aille, allons, allez, qu'ils aillent.*
Subj. Pres. : *que j'aille, que tu ailles, qu'il aille, que nous allions, que vous alliez, qu'ils aillent.*
Imperf. : *que j'allasse.*

The imperative *va* takes *s* when followed by *y* : *vas-y*, go there. The compound tenses of *aller* are conjugated with the auxiliary *être*.

A verb of frequent occurrence in a number of idioms, *aller* is used in connexion with another verb in the infinitive, to express a proximate future, and then means "to be going to," "to be about to," "to be on the point of": *je vais vous le donner*, I am going to give it to you; *j'allais vous écrire*, I was going to write to you.

Aller also means "to suit," "to fit." It is frequently used instead of *se porter*, with reference to the state of health: *son habit ne lui va pas*, his coat does not fit him; *comment allez-vous? Comment vous portez-vous?* How do you do?

Aller is used in the following expressions: *aller se promener*, to go for a walk; *aller à pied*, to walk (go on foot); *aller en voiture*, to drive; *aller à cheval*, to ride; *aller en bateau*, to go for a sail; *y aller de* (impersonal), to be at stake: *il y va de la vie*, life is at stake.

The imperative of *aller* is used to form interjections: *Va! Allez!* Believe me; I can tell you; surely. *Allons!* Come! Come now! *Allons donc!* Get away! Nonsense!

2. S'EN ALLER, to go away, *s'en allant, s'en étant allé.*

Ind. Pres.: *je m'en vais, tu t'en vas, il s'en va, nous nous en allons, vous vous en allez, ils s'en vont.*

Past Indef.: *je m'en suis allé, tu t'en es allé, il s'en est allé, elle s'en est allée*, etc.

All the other tenses are conjugated in this way, by putting *m'en, t'en, s'en, nous en, vous en, s'en* between the subject and the verb.

Imperative (positive): *va-t'en, qu'il s'en aille, allons-nous-en, allez-vous-en, qu'ils s'en aillent.*

Imperative (negative): *ne t'en va pas, qu'il ne s'en aille pas, ne nous en allons pas, ne vous en allez pas, qu'ils ne s'en aillent pas.*

The following examples will show the order of the words in interrogative and negative forms:

T'en vas-tu? Are you going away? *S'en est-il allé?* Has he gone away? *Je ne m'en vais pas*, I am not going away; *ils ne s'en seraient pas allés*, they would not have gone away; *ne vous en irez-vous pas?* Will you not go away? *Ne s'en est-elle pas allée?* Has she not gone away?

3. ENVOYER, to send, *envoyant, envoyé, j'envoie, j'envoyai.* The only irregular tenses of this verb are the future and the conditional.

Future: *j'enverrai.* Conditional: *j'enverrais.*

KEY TO EXERCISE IN LESSON 35.

1. Quand les anciens assiégeaient une ville, ils battaient les murs à coups de bélier. 2. On n'est jamais battu sans être frappé ; mais on peut être frappé sans être battu. 3. Le muletier qui nous servait de guide battait ses mules d'une façon épouvantable. 4. Nous n'avons rien conclu, mais ce n'est pas ma faute. 5. C'est un auteur dont les ouvrages ont été traduits dans toutes les langues. 6. Selon un écrivain distingué, si vous traduisez toujours, on ne vous traduira jamais, et cependant, un autre écrivain tout aussi distingué a dit que si vous voulez qu'on vous traduise un jour, vous devez commencer par traduire vous-même. 7. Je ne l'ai vu qu'une fois, mais je le connaîtrais entre mille. 8. Cette jeune fille coud, chante, lit; c'est tout ce qu'il lui faut être heureuse. 9. Qui est-ce qui disait que, partout où la peau du lion ne suffisait pas, il fallait y coudre la peau du renard, c'est à dire joindre la ruse à la force ? 10. Il y a des hommes qui ne comptent le reste des hommes pour rien, et ne croient être nés que pour eux-mêmes. 11. Un honnête homme qui dit oui et non mérite d'être cru ; son caractère jure pour lui. 12. Tout auteur qu'on est obligé de lire deux fois pour l'entendre écrit mal. 13. Ce qui est écrit est écrit veut dire qu'on ne peut rien changer à ce qui est écrit. 14. Il est admis par tous les peuples civilisés que la personne d'un ambassadeur est inviolable et sacrée. 15. Vous nous peignez si bien les charmes de la vie champêtre que vous nous donnez l'envie d'aller habiter au village. 16. Les Gaulois se transmettaient les nouvelles en allumant des feux sur les hauteurs. 17. Les jours croissent du vingt et un décembre au vingt et un juin ; ils décroissent du vingt et un juin au vingt et un décembre. 18. Les hommes sont comme les fleurs qui paraissent et disparaissent avec une incroyable rapidité. 19. Le onze novembre mil cinq cent soixante-douze, une étoile nouvelle apparut tout à coup dans le ciel, où elle brilla du plus vif éclat ; elle disparut au mois de mai mil cinq cent soixante-quatorze après avoir duré seize mois.

Our Course in French is continued in Volume 5.

GEOGRAPHY

LESSON 22

China and Japan

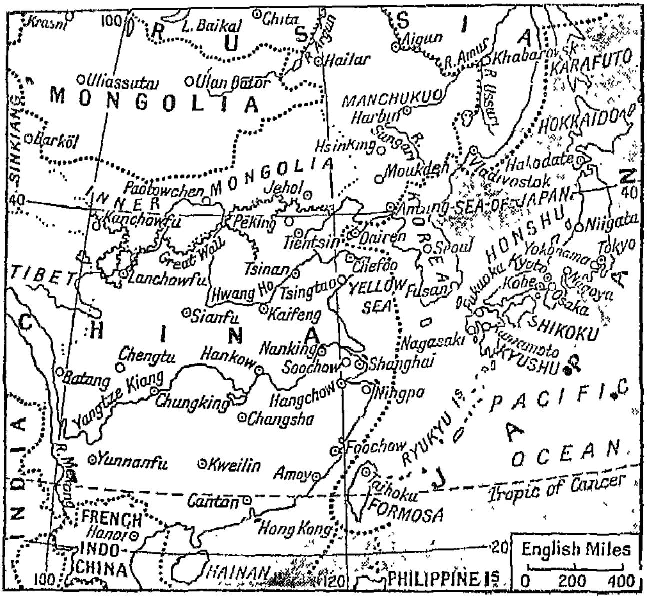
CHINA the land of famine, Japan the Britain of the East: what a contrast! China a tenth of Asia, equal in size to two-thirds of Europe, set over against Japan, which totals a tenth of the area of China and of which the islands are rather greater in area than the British Isles. China with a population almost as numerous as that of Europe, with five times as many people as Japan, which yet contains as many folk as Germany, Holland and Belgium together.

Physically, Britain is part of Europe, for the continental shelf is covered with shallow seas and the British and continental shores are accidental to the present sea-level of the North Sea. Physically, Japan is severed from China, for the Japanese islands are a Pacific festoon of partly submerged mountain chains running parallel to the mountains of the mainland. The Japan Sea is deep, and the shore lines are relatively permanent and lack coastal plains and neighbouring sea shallows. Britain has always been mainly attracted towards the North Sea; Japan has developed with her back, as it were, to the Sea of Japan. The Low Countries' alluvial flats, made from the off-scourings of inland heights, lie open to Britain; the corresponding alluvial flats of China, the lower ends of the valleys of the Hwang Ho and the Yangtze, are faced by an end-on Japan, with the Korean massif separating the Yellow and Japan Seas.

Centres of Population. Tokyo, capital of Japan, is much the largest city in the Far East; its population is approximately 6½ millions. Shanghai, largest city in China (population 3½ millions), is challenged by Osaka, a Japanese manufacturing centre. Peking and Tientsin compare with Nagoya and Kyoto, all with populations in the neighbourhood of 1½ millions; then, at the ½ to 1 million level, Canton and Hankow are equivalent to Kobe and Yokohama; smaller places than these, with populations less than 300,000, are fewer in China than in Japan, where many towns have become small urban centres since the opening of this century. Of these are Sapporo, Kumamoto, Fukuoka; Taihoku, in Formosa, and Dairen, in the Kwantung

peninsula, are each inhabited by about 200,000–300,000 folk. In contrast with Europe neither area has many large centres of population.

China is, roughly, a rectangle between 20° N. and 40° N., i.e., the latitudes of Port Sudan and Istanbul, and between 100° E. and 120° E. In the west Arabia and Iraq are lands of hardship, naturally useless, for the scanty population is relatively too numerous for the sterile land, in the east China, a moun-



SKETCH MAP OF CHINA AND JAPAN

tainous land, with monsoon rains in summer and prolific vegetation, is yet a land of famine; the most numerous population in the world is relatively too numerous even for a land of great natural fertility; in both cases Man is more numerous than Nature warrants, and hardship and famine ensue, with consequent poverty and surplus of human toil for scanty natural return.

By reason of its size and population China must be compared statistically with all Europe; the official figures are largely guess-work, especially since Japan's invasion. Less wheat is produced than in the U.S A., and much less than in Russia; the

production of rice is estimated to equal that of India—and rice has to be imported from Japan; but the quantity of tea grown is double that of the world's second largest producer—British India; the yield of cotton is, roughly, equal to that of Egypt, but less than that of India · the tonnage of coal mined equals that of India and is less than that of Japan. To the modern business world China is important, because it has very large coal deposits and the second largest iron deposits in the world. Some day these may be properly developed. China is responsible for three-fourths of the world's production of antimony; although China produces a sixth of the world's raw silk, Japan produces many times as much

The world-wide commerce of western Europe is based upon extensive trade within the political boundaries of each country. There is no counterpart of such trade in China, where means of communication are primitive, where river boats on the great navigable rivers are sail-driven or man-propelled or dragged—sampans and junks are not comparable with canal barges on the Continent or trains throughout the West; coal may be hand-picked from an exposed seam by the side of the track, yet transport costs are so high that it is unsalable twenty miles away. The villager gluttonously gorges himself when his rice crop is exceptional, though within a radius of twenty miles there may be five villages where people are starving, for there is no commercial instinct or organization, no public or official administration which tempts the villager to dispose of his surplus harvest in any other manner. In earlier, brighter days the port of Shanghai did as much trading as the rest of the Chinese ports, and yet the value of the trade ranked with that of Cardiff or Bordeaux. The commercial uselessness of China is accentuated by the resolute development of the West towards synthetic-controlled production on a large scale of highly artificial things that the trading world demands; the gap between the Western manufacturer and the primitive Chinese purchaser widens rapidly.

Japan is trying to fill the gap, and to extend territorial influence to the mainland. The Japanese Empire includes the peninsula of Korea on the continent and the festoon of islands which stretches in characteristic fashion from lat. 50° N. across the island of Sakhalin (Japanese, Karafuto), through Hokkaido to Honshu, the largest island, and Shikoku to Kiushiu, lat. 32° N., and on by the Ryukyu string of islets to Formosa (Japanese, Taiwan),

while Manchukuo is a puppet kingdom. Lying in lower latitudes than Britain, Japan has a rainfall which increases from north to south with a summer maximum, winter temperatures of 40° F., as in England, between Shikoku and Kiushiu and 20 degrees of frost in Karafuto, summer temperatures of 60° F., as in England, in Hokkaido, increasing to tropical temperatures in excess of 80° F. in Formosa.

The narrowness of the islands, with their great range in latitude, coupled with their position on the western side of one of the great northern ocean basins, gives Japan an unexpected climate of extremes. The corresponding stretch on the western side of the Atlantic Ocean would be from Newfoundland through the Bermudas to the Bahamas, a tract of ocean traversed by the Gulf Stream; the Japanese Kuro Siwo, a corresponding warm ocean current, skirts the eastern shores of the islands from Formosa northwards.

Japan's Economic Position. The produce of Japan is of great variety; in the following summary the fraction or number in parentheses indicates the proportion between Japan and the corresponding area in Europe of Germany, Holland and Belgium. Japan produces wheat ($\frac{1}{4}$), i.e. one-fourth of the European quantity. Japan produces barley ($\frac{1}{2}$), potatoes ($\frac{1}{16}$), rice (a fourth of the yield in India), tea (a fourth of the Indian quantity), tobacco (4) (a quarter of it in Korea), cattle ($\frac{1}{4}$), coal ($\frac{1}{12}$), copper ($2\frac{1}{2}$), zinc ($\frac{1}{6}$). Japan has a longer total mileage of railway than China ($\frac{1}{6}$); the effective tonnage of Japan's merchant fleet exceeds that of the European counterpart. Japan uses rubber ($\frac{2}{3}$), raw cotton (1).

LESSON 23

Physical Features of Northern Asia

NORTHERN Asia is the major portion of the shore-lands of the Arctic basin. Within circle 80° N. there is little land and a deep sea basin a couple of miles in depth. The Arctic Circle, which is 66½° N., crosses Europe in Norway, crosses Greenland, almost separates the Canadian islands from the Canadian mainland, crosses the Alaskan Mts. and Bering Strait, and encloses the tundra (barren, partially frozen plain)

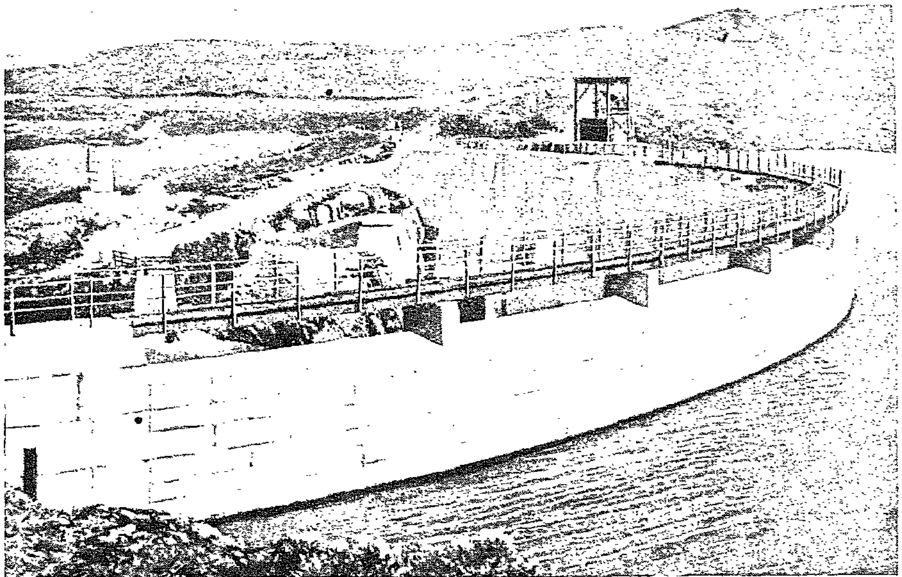
strip of northern Asia, a strip which is 600 miles wide in parts, and rises very gradually from shallow seas to the lower heights of the north of Siberia. Along this coast are the North-West and North-East passages, routes now being explored by Soviet Russia. The Asiatic section extends for a third of the way round the world, from 60° E. to 180° E.

South of the Arctic circle to 45° N., half-way between pole and equator, Asia extends inland, slow-climbing to the Tien Shan, with its north-eastern extensions, the Altai, etc. South of these first heights are the basins: in the west, the lowland basin of the Aral and Caspian Seas, of Turkestan; in the middle, the elevated Tarim basin, which has the "Roof of the World" at its south-west corner; in the east, the Gobi in Mongolia.

Rivers and Lakes. From Mongolia flow out the Chinese river Hwang Ho and the Siberian Amur, to the Pacific Ocean. North of the basins are the great rivers Lena, Yenesei, and Ob-Irtish, mainly useless to Man from winter frosts and summer floods and outlets to an ocean back-water, all exceeding 2,000 miles in length. Into the Sea of Aral flow the Amu-Darya (Oxus) and the Syr-Darya. Lake Baikal fills a highland trough and outflows to the Yenesei; it is one of the largest fresh-water lakes in the world, and is frozen over with thick ice in winter.

Between Lake Balkash and the European frontier is the Kirghiz Steppe, the home of the Kirghiz. Round Tobolsk, on the middle Ob, are the Tartars, who extend eastwards through Tomsk to Irkutsk and Yakutsk. Between the Ob and the Yenesei are the Ostyaks, and between the Yenesei and the Lena the Tunguses. Fringing the Arctic are the Samoyeds, the Yakuts and the Yukagirs. These are the native folks among whom Slav immigrants and others have made their homes.

The whole of northern Asia is frost-gripped at sea-level temperatures, in January; northwards the frost is more severe, until the zone of maximum cold, with 60 or more degrees of frost in January, is reached in the lower Lena valley. This is colder than corresponding latitudes in Canada. In summer, temperatures run high for a few weeks, as in Canada; Labrador's inclement climate is paralleled by the north-eastern peninsula, where the climatic rigour is emphasized by the Stanovoi Mts.; both are at the north-west corner of a great ocean basin. In the three inland basins, with their aridity and clear skies, the summer temperatures rival those of Iraq and Arabia.



MAENTWROG DAM. Fig. 5. This photograph shows the upstream face of the main dam of the Maentwrog undertaking of the North Wales Power Co., Ltd. The dam is built of concrete on a rock foundation, and the maximum height of the spillway crest above the stream bed is approximately 90 feet. ENGINEERING 25

Glenfield & Kennedy, Ltd., Kilmarnock

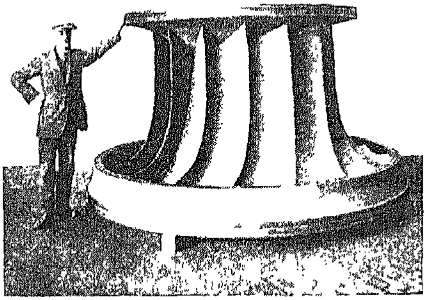
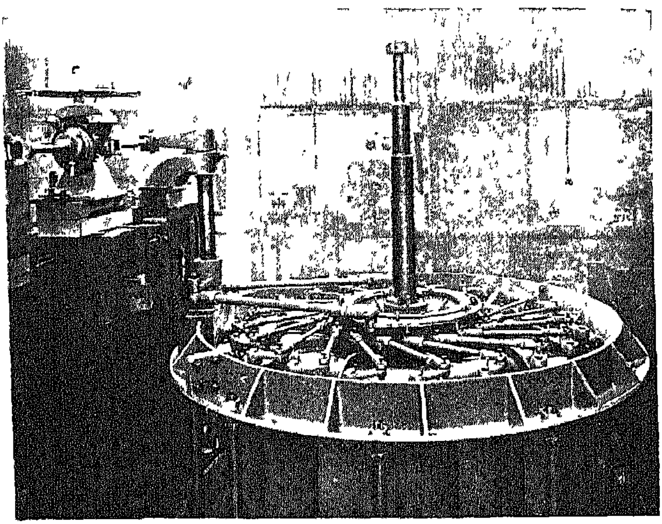


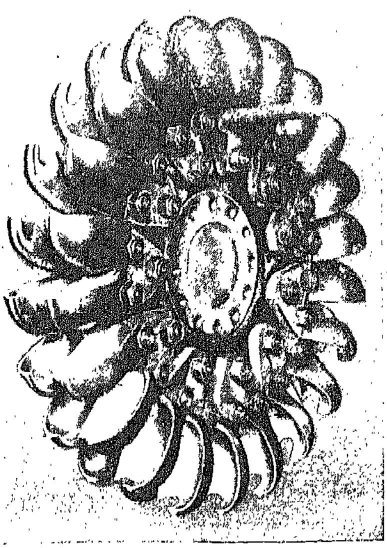
Fig. 3. A large water turbine runner It has an exit diameter of 10 feet and weighs $5\frac{1}{2}$ tons ENGINEERING 26

Courtesy of The English Electric Company Ltd



WATER-TURBINE INSTALLATIONS Fig. 2 The gate apparatus in course of construction ENGINEERING 26

Courtesy of The English Electric Company Ltd



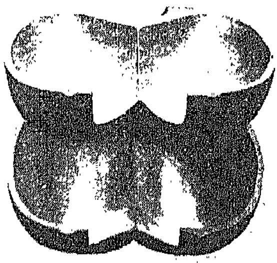
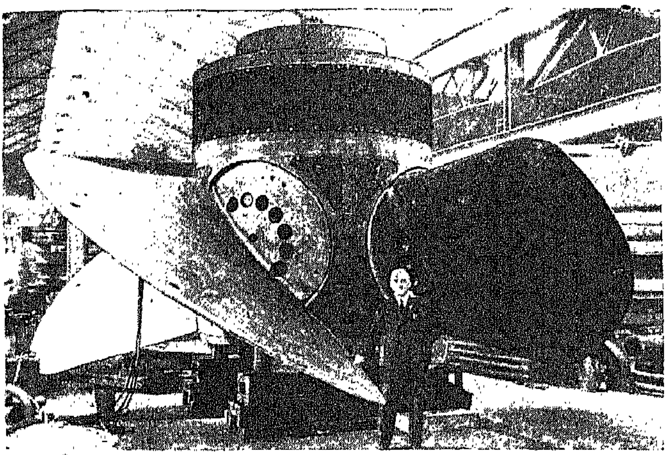


Fig. 1 (left). Close-up view of the Pelton runner, clearly showing how the buckets are arranged and secured in position. **Fig. 2** (above). One of the stainless steel double buckets. ENGINEERING 27

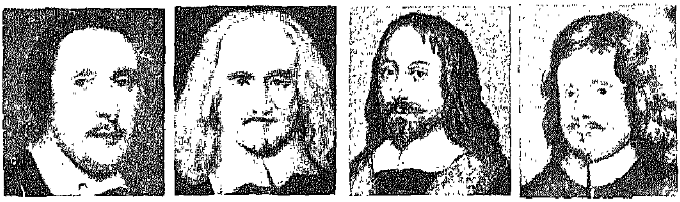
Courtesy of "The Engineer"



WATER TURBINES. Fig. 4. Said to be the largest water turbine runner yet built, this Kaplan runner develops 37,500 h.p., with a head of water of roughly 36 feet, running at a speed of 75 revolutions per minute. ENGINEERING 27

Courtesy of "The Engineer"

POLEMICS UNDER THE TUDORS. Left to right: John Wycliffe (c. 1325–84) began in 1378 the first translation of the Bible into English. William Tyndale (c. 1492–1536), a one-time priest, translated the New Testament and the Pentateuch into English. Forced to leave England, he took refuge abroad, but at the instigation of Henry VIII he was charged with heresy, strangled, and burnt at the stake. John Foxe (1516–87) issued in 1563 a "History of the Acts and Monuments of the Church," since widely known as "Foxe's Book of Martyrs." Richard Hooker (c. 1553–1600) endeavoured in his "Ecclesiastical Polity" to provide a philosophical and logical basis for the remodelled Church of England. ENGLISH LITERATURE 29

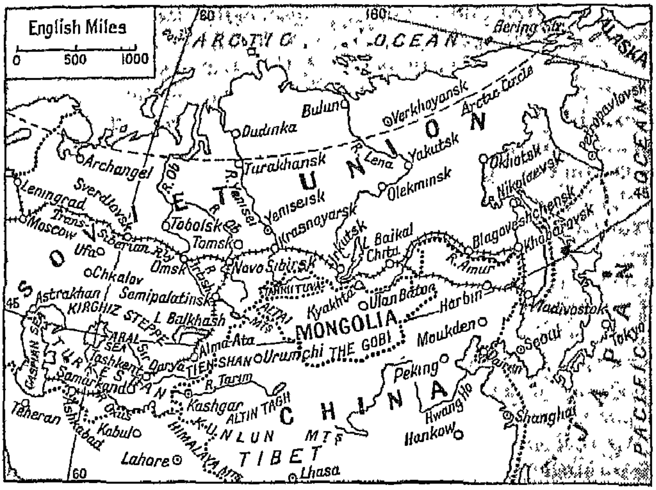


SOME JACOBEAN PROSEMEN. Left to right: Jeremy Taylor (1613–67), bishop of Down and Connor, wrote 36 prose works, of which the most famous are "The Rule and Exercises of Holy Living" and "Holy Dying." Thomas Hobbes (1588–1679) was one of the most famous and influential of English philosophers. In his "Leviathan" (1651) he advocated the complete supremacy of the Sovereign Power in Church and State. Sir Thomas Browne (1605–82) a Norwich physician who achieved distinction by his "Religio Medici" (1642), an attempt to reconcile faith and reason, and "Urn Burial" (1658). John Bunyan (1628–88), author of some sixty books, is chiefly famous for "The Pilgrim's Progress," a picture of the prevalent spiritual problem of the age, and its characteristic solution. ENGLISH LITERATURE 29

SEVENTEENTH CENTURY PROSE WRITERS. Left to right: Francis Bacon (1561–1626), whose "Essays" deal with the essentials of life as recorded by a man of the acutest intellect. John Evelyn (1620–1706), who is chiefly remembered for his Diary, covering the years 1640–1706. Samuel Pepys (1633–1703), a still more famous diarist, whose work, however, covered only the ten years from 1659. Izaak Walton (1593–1683), author of some of the most delightful of English biographies and of the "Compleat Angler: or the Contemplative Man's Recreation." ENGLISH LITERATURE 30

Tibet. South of the basins is Tibet, the highest plateau in the world, with its mountain rims to the north, the Kunlun and the Altyn Tagh, and to the south, the Himalayas, and an average height of 15,000 ft. There throughout the year the actual temperatures are usually below freezing point, and this plateau, over two miles above sea-level, is a perpetual storehouse of heavy, cold dry air in the dead heart of Asia. The basins are mainly desert or poor steppe; north of them is the steppe or pure grassland, nowhere so wide as it is north of the Black Sea.

Farther north is the mixed woodland and grassland and beyond is the coniferous forest, reputed to be as rich in timber as the forests



SKETCH MAP OF NORTHERN ASIA

of Canada used to be. On the shore is the tundra. The Pacific coast is harsh, it consists mainly of the Sea of Okhotsk, includes the north of Sakhalin and the Gulf of Tartary, and reaches the Sea of Japan at Vladivostok, the only port free from ice in winter.

The western basin and the northern slopes contain the Siberian Soviet States, for the boundary gives the middle and eastern basins to China. The area totals half of Asia, as great an area as North America. Here live as many people as in Great Britain,

a quarter of the numbers who inhabit North America, one-twentieth of the population of Asia as a whole.

Tashkent, the largest town, has 500,000 people and compares with Madras. Novosibirsk, Omsk and Vladivostok have each over 200,000 inhabitants, and are comparable with Karachi. Other places are smaller; such are Krasnoyarsk, Chita, Blagoveshchensk, Khabarovsk, Samarkand and Irkutsk.

The main usefulness of the area occurs in the west, where European Russia continues eastwards. The statistics are, for many and varied reasons, obscure; but, in general, the Asiatic territories produce about a fifth of the corresponding production in European Russia. Cereals such as wheat, barley, oats are grown. Cotton and cotton seed, flax and linseed are produced. Farm animals include horses, cattle, sheep and goats and, relatively less frequently, pigs. Butter is produced and exported.

Trans-Siberian Railway. One of the main features of interest is the trans-Siberian railway, an overland connexion between Moscow and the Pacific coast at Vladivostok and Dairen. Like its forerunner, the Canadian Pacific Railway, it keeps as far south of the Arctic as political and physical exigencies permit, and so it runs across the southern edge of the Arctic Basin, through the steppe and the mixed woodland and grassland, where there is some likelihood of local traffic. Great physical difficulties were encountered in the section round Lake Baikal, where the rocky character of the lake-trough was overcome by many tunnels and numerous roofed-in cuttings. The total length is more than 5,000 miles, and the capital sunk in construction exceeded £85,000,000.

Apart from modern institutions such as the railway, the semi-westernized farms and the municipal organization of the growing villages, the area is a land of caravan transport and fairs, with some exploitation of wild and domesticated animals in the form of furs and skins—mainly of purely local interest as a relic of bygone glories. It is believed that the area has been subject to a progressive desiccation, and that the basins, at least, once provided homes for a more numerous population. Various explorers have unearthed evidences of former activity excellently preserved in the dry soil and the dry atmosphere. Tibet is a backwater which epitomizes this view of central Asia. Lhassa to the Buddhists, like Mecca to the Mahomedans, is the holy of holies, although it is less accessible than the Arabian city.

LESSON 24

The Three Americas

THE Americas, North, Central and South, together extend from 80° N. to 70° S.—150°, or 10,000 miles. This extent includes the South Shetlands and the Graham Islands south of Cape Horn. In the north its width is 140°, some 2,000 miles. Along lat. 49° N., part of which is the boundary between the U.S.A. and Canada, the continent is some 3,000 miles across, through 70° of longitude, i.e. 5 hourly time zones. At the tropic of Cancer, though the width in longitude is but 30°, the width in miles is about 2,000. In reality, North America is somewhat barrel-shaped some 3,000 miles north to south—New Orleans to Baffin Land. Between Port Arthur and Winnipeg is the centre of this mass of land.

Central America is a mainland isthmus which almost disappears at Panama and the West Indian Islands. South America, at the level of Trinidad, is 15° across, 1,000 miles; at the equator, level with the Amazon mouth, it is twice as wide; 5° farther south, at the level of Cape San Roque, it is three times as wide; there it is 3,000 miles across, as wide as the widest part of North America. Thence southward it narrows steadily. From Buenos Aires to Trinidad is about 3,000 miles, Cape Horn being more than 1,000 miles farther south.

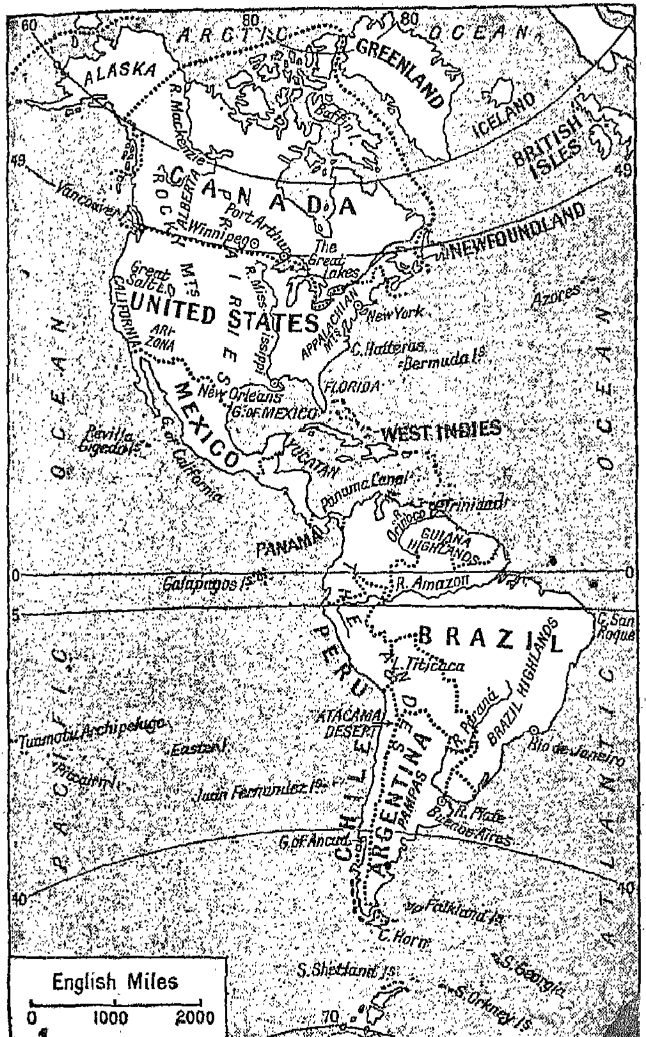
The continent has shores on three oceans. Along the north it forms the rim of the Arctic Basin, which is over a mile deep and which has no coastland over a mile high, except in northern Greenland. Were the waters of the basin to become 600 ft. deeper most of the Canadian islands would disappear, and the Arctic waters would lap some of the sleepers of the Canadian Northern Railway. The whole of this submersible area is practically useless as the home of Man. It has 40 degrees of frost in mid-winter, and the midsummer temperature does not usually exceed 50° F. It is the region of the tundra or cold desert, a frozen winter waste, and, however explorers and travellers may extol the verdant patches that adorn the valleys during the short summer, an area which grows with the closest attention potatoes no larger than walnuts is not very useful to many people. It has

been suggested that caribou farms to supply New York with caribou steak and silver fox farms are resources for the tundra, but the long winter nights induce hibernation and stagnation. There are few people north of 60° N.

West of the Great Lakes the Height of Land marks the true edge of the irregular Arctic Basin, and separates it from the great flatness across which the Mississippi drainage system wanders towards the Mexican Gulf.

Pacific Coast. The Pacific coast of America has definite characteristics. It is backed throughout with high ground—at its widest some 800 miles across—which is a mile high and has many patches above two miles above sea-level. This high area, the Rockies and the Andes, and their connexions and outliers, are scarp-edged to the east and cut up and diversified to the west. Between the rim and the coast are many upland and lowland basins, some with internal drainage, as into the Great Salt Lake, others with narrow gorges as outlets, all more or less longitudinal, running from north to south along the axis of the heights. Some of these valleys have been drowned, as the Gulf of California and the Gulf of Ancud; others lie trough-like between coastal ridges and the inland heights, as the valleys of California and Chile; some have almost lost their identity, as the western side is but a festoon of islands off the coast. From the shore the Pacific drops quickly, there is practically no continental shelf, and the tidal variations are unimportant. Here the valleys outside the trade wind belt are fertile, usually with typical winter rains, as in California and Chile, and wherever the rainfall suffices, the slopes are forest-clad. These coast lands are suited to be the homes of fishers, foresters and fruit farmers. Since the heights are relatively young folded mountains, they are metalliferous; gold, copper, petroleum, etc., stimulate growth of population, which originally came to these lands by sea, for the connexions by trans-continental railways with the more populous east are comparatively recent, especially in the south and extreme north.

Atlantic Coast. The Atlantic shores are different. The continental shelf is wide; it includes, for example, the Falkland Islands. The coastal lowlands are similarly wide, and the conformation of Delaware and Chesapeake Bays and of Cape Hatteras bespeak gentle slopes across which the actual tide level is an accident of the slight variations in contour. Florida and Yucatan are both lowland peninsulas. In Mexico the eastern scarp-edge


ARCTIC OCEAN
ALASKA
GREENLAND
ICELAND
BRITISH ISLES
CANADA
R. Mackenzie
ALBERTA
Vancouver
Port Arthur
Winnipeg
The Great Lakes
NEWFOUNDLAND
ROCKY MTS
PRAIRIES
R. Mississippi
Great Salt L.
UNITED STATES
CALIFORNIA
ARIZONA
APPALACHIAN MTS
New York
C. Hatteras
Bermuda Is.
Azores
FLORIDA
New Orleans
G. of MEXICO
MEXICO
WEST INDIES
Revilla Gigedo Is.
G. of California
YUCATAN
Panama Canal
Trinidad
R. Orinoco
GUIANA HIGHLANDS
PANAMA
Galapagos Is.
R. Amazon
PERU
BRAZIL
C. San Roque
L. Titicaca
BRAZIL HIGHLANDS
R. Paraná
Rio de Janeiro
ATACAMA DESERT
Tuamotu Archipelago
Easter I.
Pitcairn I.
Juan Fernandez Is.
CHILE
ARGENTINA
PAMPAS
R. Plate
Buenos Aires
G. of Ancud
Falkland Is.
C. Horn
S. Shetland Is.
S. Georgia
S. Orkney Is.
PACIFIC OCEAN
ATLANTIC OCEAN
English Miles
0
1000
2000

of the Pacific heights reaches the Gulf Coast. The northern coast—the coast north of the equator—of South America on the Atlantic is reached by bifurcating spurs of the Andes with longitudinal valleys, as far as Trinidad; then come the Orinoco lowlands, backed by the Guiana highlands. Thence to the south-east from the Amazon delta lie the Brazil lowlands.

The remainder of the coast of Brazil, south of Cape San Roque, is defined as an eastern bulge of the continent by the Brazil heights; this downland country rarely reaches a mile in height, yet has a wider coastal plain and a wider undersea shelf than Peru and Chile.

The Argentine coast at first is low, and, here, a slight change in ocean levels would reproduce the Gulf Coast, with the Plate to parallel the Mississippi; south of 40° S. the inland is plateau; the coastal sill is narrow above the sea level, but wide below it. The Atlantic coasts are accessible from the ocean and lead inland, except in the neighbourhoods of New York and Rio de Janeiro. Fishers, foresters, traders, farmers on the small scale prevalent in Europe, can here thrive, and the cultivation of the crops—cotton, tobacco, coffee—to which these coasts are peculiarly suitable, provides an additional incentive to growth in population; here has grown the greatest settlement of Europeans overseas. The middle of both North and South America is lowland with very slight heights of land separating the immense drainage basins—Mississippi, Mackenzie, Amazon and Plate. The interior lowlands, by their extent, by their north and south range, by their nearness to oceanic influence, are cultivable and arable land.

Of these interior lowlands the basin of the Mississippi is a unique world phenomenon. For all practical purposes, the basin is flat; nowhere else does flat land extend so far in all directions. Across it sweep the winds, sometimes with tornado strength. Across it, in the main from east to west, run human traffic lines, rail and road and air-route. On it has developed the greatest world example of mechanized farming, with the result that the requirements of the farmers of this area tend to dominate the labours and limit the outlook of the white man everywhere in the world. On it has grown the world's greatest belt of raw cotton.

Climate of the Continent. Climatically, America should show the climatic regions in pairs; there is only one equatorial hot wet area, the Amazons; there is only one tundra, along the Arctic; the deserts pair, the Atacama in the south and the semi-arid

Arizona, etc., in the north; the Mediterranean regions pair in central Chile and in California, the inland summer rain regions pair in the middle lowlands, though the transition from the hot winters of the Gulf States to the frost-bitten winters of Alberta is not so definite in the south, where the tapering land means more definite sea modification of winter's rigours. In relatively similar latitudes to Britain are Newfoundland and Vancouver in the north and the Falklands in the south, but none of these insular areas has the amenities of the British climate, due to Britain's unique combination of westerly winds, westerly ocean drifts, the wide continental shelf and the shallow seas; none is so suited to be the home of a progressive population.

The tropical forest of hardwoods is of relatively little value, for the wood is not salable on the grand scale and the rubber has been superseded. The coniferous and deciduous forests are being depleted, and a dearth of soft woods of American origin is not merely threatened, but is certain, for there is little or no afforestation or forest conservation. The pampas, the warm summer-rain grassland of the south, yields cattle, sheep and wheat, and is one of the great producers of meat, wool and cereals of the southern hemisphere. The corresponding warm summer-rain grasslands of the north in the lower Mississippi basin contain the cotton, tobacco and maize belts, which extend as the wheat belt until they reach the prairie, where the grass land is frozen in winter.

Minerals occur haphazard. In the Appalachian system behind the Atlantic coast in the U.S.A. is one of the greatest coal deposits in the world, and associated therewith is the highly mineralized area near the Great Lakes, where iron ore is steam-shovelled in quarries, and where, for example, the bulk of the world's nickel is mined. Copper, silver and gold occur in the western heights.

The bulk of the people are of immediate or ultimate European origin; the south is sometimes referred to as Latin America. In the north, especially in the U.S.A., the world is witnessing a vast attempt to absorb a heretogeneous mass of folk and to weld them into one union, for the States have had their negroes from slave-trading days, they have had Teutons for centuries, and, more recently, they have received Slavs and others from central Europe. The process of amalgamation proceeds slowly, and the influx of alien people is temporarily in check and under control.

LESSON 25

British America's Marginal Belt

THE boundary line between Canada and the United States begins on the Pacific Coast at 49° N., passes through four of the Great Lakes and south of the St. Lawrence, and swings south to the Bay of Fundy. North of this line to the rim of the Arctic Basin is Canada, with the exception of Alaska on the west, which is United States territory, Labrador and Newfoundland on the east, and Danish Greenland; Newfoundland and Labrador, although British, are not part of the Canadian Dominion Only the narrow belt fringing the boundary is of real importance, and then only as a marginal land.

Physically, the land rises towards the south, and with the exception of the St. Lawrence on the east, a rocky flume from the Great Lakes to the Atlantic Ocean, and the rivers of the British Columbian slopes on the west, the drainage is Arctic; from Winnipeg to the Alaskan edge near the mouth of the Mackenzie is the line of the lake system: Winnipeg, Great Slave Lake, Great Bear Lake, and the connecting rivers. From this line the land rises in terraces to the Rockies.

Naturally, there is tundra vegetation in the north, with temperate forest over most of the rest of the country towards the narrow marginal strip, where mixed woodland, grassland and cultivation merge on the frontier in the middle of the continent into the prairie, the great American rolling grassland subject to summer rains and winter frost. The higher ground of the Rockies and British Columbia on the west and of the Maritime Provinces on the east is forest-clad, as is also Newfoundland; Labrador is tundra Ice is a nuisance in Hudson Bay, and in the Greenland and Labrador seas. The actual mid-winter temperatures are zero or below; there are over 30 degrees of frost, everywhere except along the margin, where the temperature in January is still 10 degrees of frost at least, and this in the latitudes of southern England. The actual temperatures in July range from 40° F. in the north to about 65° F. on the frontier.

British Columbia is, on the whole, cooler than Britain, and has most of its rain, which is in total the maximum for the country,

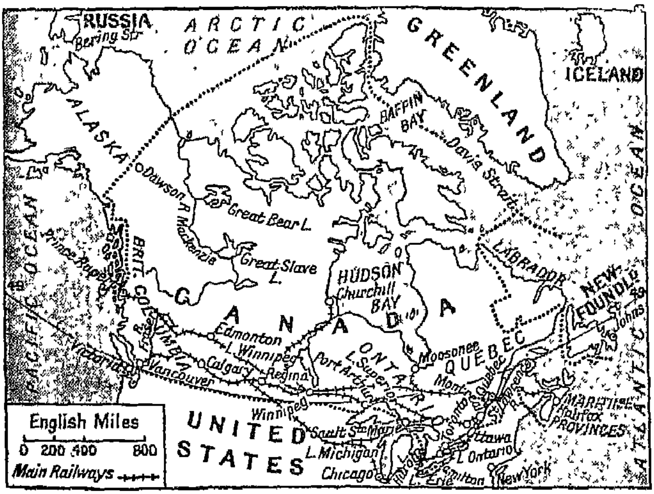
during the cold weather. The Maritime Provinces, Nova Scotia, New Brunswick, and Prince Edward Island, are similarly cool with evenly distributed rainfall; they are, therefore, marginal lands, comparable with the Baltic countries in the matter of cultivation. The north is dry, and the southern interior margins experience smallish amounts of rain during the hot weather; the line of increasing rainfall in the summer extends from the mouth of the Mackenzie, through Winnipeg, into the United States, to terminate in Florida.

Distribution of Population. This physical marginal limitation is reflected in the distribution of the population, which does not exceed two persons to the square mile, except along the margin and in the Lake Erie-Ontario-St. Lawrence stretch. Most of the Canadian cities with a population in excess of 100,000 lie in this stretch: Montreal, the commercial capital, has more than a million folk, yet fewer than the U.S. Detroit, Toronto, with 700,000, is comparable with the U.S. Pittsburg; Hamilton, Ottawa, the political capital, and Quebec, the French-Canadian centre, have each less than 200,000 inhabitants, and are comparable in size with Miami, Duluth, and Albany in the U.S.A. On the Pacific coast is Vancouver, with almost 300,000 people, yet smaller than the neighbouring Seattle and Portland across the border, and but half the size of San Francisco. Inland is Winnipeg, the "mushroom" queen city of the prairie, a railway centre, and a focus for the Canadian grain trade, the third city in the Dominion, with some 280,000 people, yet smaller than the U.S. Portland. Calgary, also inland, in the lee of the Rockies, the ranching centre, hardly tops the 100,000 mark.

A total population of some ten million souls is attenuated throughout this marginal area, and is in striking contrast with the agglomerations of similar numbers of people in Belgium and Holland or in Yugoslavia and Rumania. What Canada needs most is an appreciable increase in population.

Politically, Canada is a long east-west strip, on every other count it is the northern marginal edge of the core of the North American continent. For political reasons Canadian effort is directed northwards and north-westwards into areas which are still more definitely marginal, where human effort is guaranteed a problematic and exiguous return, and where large-area rather than large-scale production alone can pay. The political boundary is really an accidental line across the natural regions.

On the west, British Columbia has its salmon rivers such as the Fraser, its lumbering camps, its orchards, and is the northern portion of a natural region which extends south to Washington and Oregon. The Canadian ranching and wheat areas on the prairie reach across the border into the wheat belt of the U.S.A.; the wheat farmer on each side of the frontier is equally dependent for his financial success upon the ratio of world supply to world demand for wheat. The mineralized Canadian area centring on Sudbury is marginal to the great mineral area of the Ohio and Pennsylvania. The Lakes Peninsula and the neighbouring St.



SKETCH MAP OF BRITISH NORTH AMERICA

Lawrence banks have their fruit orchards and their dairy farms in close relation to similar occupations under more favourable conditions farther south. The Maritime Provinces, with their orchards, lumbering and small collieries, share with the neighbouring States in the fishery of the Grand Banks.

Quebec and Newfoundland, with their lumbering, wood pulp, and paper industries, are not alone and isolated, although destructive exploitation in Canada has not yet bared the land of its natural resources, as in more southerly districts. Politically, Canada exists to supply the British Isles with primary produce, timber, grain, fruit and fish; yet, by force of imitation of her

neighbour, Canada manufactures, and her goods are necessarily competitive with those of Britain, although the establishment in Britain of branches of Canadian factories tends to mask this.

Urbanization is the sign of the growth in numbers of folk engaged in secondary occupations: clerical and other human recording machines, agents, brokers, dealers, and other workers who frequently buy and sell stuff they never see; the inevitable hierarchy of officials and similar hordes multiply and stand between the primary producer and his customers. Canada here gains as a marginal area, because the proportion of secondary to primary workers, all gaining sustenance from crops and mines, is smaller on the margin than at the centre; the primary producers should be better off.

The relative situation between Canada and the States may be well seen in a comparison between statements of affairs in 1900 and at the present time. In each numerical statement which follows, the second, bracketed, figure refers to the U.S.A.: e.g. wheat production in Canada is 7 (1½) times as great; the (1½) implies that the U.S.A. production of wheat has been increased during the same period 1½ times; Canada now produces about two-fifths as much wheat as the United States.

Barley 7 (5); oats 1 (1)—for the two are roughly equal and are stationary; potatoes 1½ (2); tobacco 3 (2)—the Canadian crop is but half that of Cuba; wool 2 (1½); horses 2 (1); cattle 1¾ (1¼); sheep 1½ (1); pigs 1½ (1¼); coal 2 (2); iron ore (Newfoundland 3, U.S.A. 2½) · copper 14 (3); lead 5 (2½); zinc — (6)—the Canadian zinc mining, now roughly a seventh of the yield of U.S.A., is a post-War development; aluminium 8 (4); gold 1½ (½); petrol 1 (15); motor-cars in use 20 (20). miles of railway in use 2 (1½); imports by value 6 (4); exports 6 (4).

LESSON 26

People and Produce of 'the States'

One of the commonplaces of nineteenth-century studies of English life and folk is the picture of the self-made manufacturer of the industrial north, purse-proud, assertive, demanding attention to his performance, his views and opinions on the ground of his successful garnering of many shekels. Out of a nondescript, muddled, huddled background he emerges on

to the national stage to achieve importance civically or politically. Of late years it is fashionable to aver that such as he suffer from an "inferiority complex," and behind this label lies the arrogance of the superior person. He is and must be different, but difference is not inferiority, he stands for vigour, youth, promise, over against the futile stupidity of soul-hardened, age-worn habit

Among nations his counterpart is the United States It is futile to imagine that the American nation suffers from an inferiority complex because it "boosts" results, achievements, capacities and resources, because it "bosses" the world's spendings on wheat and meat, on rubber and motor-cars, on paper and on footgear Out of all the Americas, of the whole of the New World, the best bit forms the United States From the Great Lakes to the great Gulf, from the Atlantic to the Pacific, within those latitudes where neither excessive heat nor excessive cold prohibits human toil, with the vast lowland of the Mississippi as the world's greatest stretch of arable land with a pair of mountain edges to this lowland, each of which contains rich store of ore and with coastlands on the two oceans of which Man makes most use—how could the States be other than different? Without the museums of moribund uselessnesses in the relics of the European feudal system, without the over-capitalization of mere acres as evidence of wealth, no matter how unproductive they be, without the constant contact with the lesser breeds outside the law, the coloured races of the Old World, without an imagined status to live up to—the American is a youth on the world's stage

His growing years have been spent farther and farther from the Old World, for the centre of the population has gone steadily to the west New York, alleged to be the greatest agglomeration of buying power the world has yet seen, is but the nexus of the links between the Middle West and Europe His growth has been achieved in relation to the concept, ' better merely because bigger ' For him, as he spread over untrodden ways, "bigger" has necessarily meant ' better,' and bigger must be interpreted as not only greater in size but larger in number bigger has implied mass-production, which means the making of much wealth by means of an infinitude of small profits Hence he has grown to a gospel of work—make things, make more things, make yet more things, and, having acquired the habit of making,

sell the things. But to sell has meant selling at the price the customer can pay, not selling at the price which the maker has demanded, and selling has become a fetish, an art exalted by its practitioners.

American hustle means production at all costs. Such large-scale production has happened because the land has been spacious and its resources almost boundless. The wheat belt, the corn or maize belt, the tobacco belt, the cotton belt, dominate the food supplies of the white man. The mines of iron, of copper, of coal, created the Ford car, which has taught the world new facts

SKETCH MAP OF THE UNITED STATES OF AMERICA

concerning transport. Wide horizons meant individual labour, reliance on self; hence America has taught the world something about farm machinery. Coupled with this dominance of self has happened the fertility of ingenuity; cotton manufacturing is said to have arisen because an emigrant was able to reconstruct cotton machinery from memory—that is in the past; today, a fishing industry related to the Grand Banks store of food fishes, an industry formerly declining from lack of organization, is promised prosperity because an inventor has perfected a method of freezing fish fillets within containers with such rapidity and cheapness that it materially adds to human food resources.

Such are the United States, a newcomer inviting the staid Old World to slough its antiquities, its habit of making war, its slavish devotion to futile formalities, which served well even the last generation

Some Production Figures. As a pageant of mere size take the comparisons fished out of the world s account books between the U S A and their next competitor a wheat total nearly that of Russia and more than twice India or Canada, production of barley, twice either Canada or Japan, production of oats, nearly that of Russia and twice Germany, maize production ten times the Argentine production of tobacco, ten times Brazil, production of cotton three times India, production of wool, equal to the Argentine and beaten only by Australia, numbers of horses, half as many again as the Argentine, beaten only by Russia, of cattle, as many as Russia, beaten only by India, where cattle are exceptional of sheep as many as South Africa or Argentine, beaten by Russia and Australia of pigs, twice as many as Germany or Russia, in tons of coal, far more than Britain or Germany of iron ore half as much again as France, of steel produced, three times Germany, of copper produced, at least ten times Germany of lead, four times Canada, of zinc, four times Mexico or Australia, of gold, beaten only by South Africa and Russia, of silver, three times Canada or Peru, beaten only by Mexico; of petrol, six times the production of Russia or Venezuela—these are resources, an unparalleled combination

Railways may be included in the pageant to represent utilities in actual mileage in use the total comes to ten times the next competitors, in mileage compared with population they are beaten by the less populous new countries, such as Australia, but exceed by five times Britain and by four times Germany, in mileage compared with area they are beaten only by congested countries of Europe such as Belgium Britain Germany and France Predominance is also shown in consumption, for much produce is sold within the country. wheat, twice as much as Britain or France sugar, three times Britain, four times Germany, coffee, four times France or Germany, cocoa, three times Britain, tea, second only to Britain, coal, three times Britain, petrol, more than ten times Russia or Britain iron, double France, rubber, five times Britain, cotton, three times Britain In a world dependent on buying and selling, the U S A. stand alone

Urban Centres. Finally comes the distribution of the people. The rank of 100,000 inhabitants is attained by over 90 places, and we must take a ranking of 250,000, roughly equal to Nottingham or Bordeaux, as a standard The U.S.A. contain metropolitan New York, which vies with London—an agglomeration which spills over from Manhattan Island across the ferry routes and by under-river tunnels and strains upwards—so great is the congestion. The U.S.A. contain, also, Chicago—which averages Berlin and Hamburg—the lakeside city which stands for wheat and pork, Philadelphia, which equals Vienna, centre for the metallurgical developments of the Alleghanies; Los Angeles, which roughly equals Hamburg, with its neighbouring Hollywood famous for the filmic art which mechanizes story-telling and literature; and Detroit, which is bigger than Warsaw, and has taught the world the necessity for good roads.

These cities all exceed a million inhabitants, and such a combination of great urban centres is only paralleled in Britain, where, on a smaller scale, London, Glasgow, Birmingham, Liverpool and Manchester exceed any other group of five cities in the world. Next in order come the middle group in the U.S.A., of which Chicago is typical; Cleveland, roughly a Birmingham; St. Louis, roughly a Cologne, Pittsburg, a greater Sheffield; Buffalo, about the size of Lyons; Milwaukee, a greater Dortmund, and then, in descending order, Cincinnati, Minneapolis, Kansas City. Indianapolis, Louisville, Toledo, Columbus St. Paul Akron, with Denver to the west, and, at the mouth of the great river, New Orleans, which rivals Edinburgh or Palermo. On the Pacific are San Francisco, on the Golden Gate, a great seaport, an ancient avenue to Japan and China, about the size of Genoa, Portland and Seattle, as big as Bristol. On the Atlantic, after New York come Boston, about as large as Manchester or Munich an Irish city, metropolis of New England; Baltimore, a seaport almost as large as Liverpool; Washington, the Federal capital, slightly more populous than Athens; and Jersey City, Newark, Rochester, Portland, complete the tale.

Our Course in Geography is continued in Volume 5.

LESSON 14

Chief Features of the Permian Period

(See plate 51)

THE Permian is the last of the Palaeozoic periods; its strata follow the Carboniferous, and were originally known as the New Red Sandstone, in contradistinction to the Old Red Sandstone of the Devonian Period, which immediately underlies the Carboniferous. Since several other formations, such as marls, breccias, limestones, dolomites and conglomerates, also enter into the composition of this geological period, the name Permian was proposed by Sir Roderick Murchison in 1841. It is derived from Perm, the old province of east Russia where these deposits are found extensively developed.

In Britain there exists a distinct break between the Upper Carboniferous and the Permian series. The highest of the Carboniferous, that is, the Stephanian facies is not present in this country, but where strata corresponding to the Stephanian exist, as in northern France, the Carboniferous passes conformably upwards into the Permian. These transition deposits are therefore, known generally as Permo Carboniferous and are present, together with the Permian in southern Europe, eastern Russia, central Asia, India, Australia, South Africa and South America. In these areas they attain great extent and thickness.

The Permian strata in Britain are composed of a terrestrial facies, which constitutes the Lower Permian, and a marine facies, known as Upper Permian. These are both present in the extensive deposits exposed in a long belt which extends from North Shields and the Sunderland area in Durham, through the centre of Yorkshire, to the border districts of Derby and Nottinghamshire. In this area the Upper Permian deposits consist of red marls, beds of salt and intercalated limestone in thin layers, the whole attaining 500 feet in thickness. They overlie a very thick bed of magnesian limestone; this reaches a thickness of 800 feet in Durham, but is much reduced farther south. These rocks are exposed, and fossils may be obtained in many areas, notably the Doncaster, Brodsworth, Cadeby, Pontefract and Tadcaster districts of Yorkshire, the Mansfield and Worksop districts of Nottingham, and at Marsden, Ferryhill, Fulwell in

Durham and the coast north of Hartlepool. Below these rocks are the Lower Permian strata, consisting of marl slates beneath which are the yellow sands, the whole about 150 feet in thickness.

The New Red Sandstones are much in evidence, intercalated with marls and breccias, in the Coventry and Kenilworth areas of Warwickshire, to the west of Birmingham, in the West Bromwich district, and in the northern part of Worcestershire. There are several outcrops in Staffordshire, notably the Clent hills, and in Shropshire, where, in the Enville area, the Permian marls, breccias and conglomerates reach a thickness of 800 feet.

In Lancashire, on the Pennine slopes to the east of Manchester and Stockport, the New Red Sandstone attains a thickness of 1,000 feet, while the marls and limestones reach to another 230 feet. Farther north, and still to the west of the Pennine ridge, the Permian rocks are found in great thickness throughout the Vale of the Eden, reaching almost to Carlisle from Kirkby Stephen in Westmorland. There the New Red Sandstone reaches 1,500 feet in thickness, while above this are thin beds of limestone and red shale. At St. Bee's Head, at Egremont, and farther south in the Clitheroe area and east of Preston are more small outcrops of these strata. The Permian rocks appear in the Isle of Man and, still farther west, in Ireland, at Cultra, near Belfast, and at Armagh and in eastern Tyrone as small patches which have survived denudation. In eastern England the Permian rocks have been found from borings to exist in Lincolnshire, where, composed mainly of magnesian limestone and marl, they were reached at a depth of 1,100 feet below the surface and extended to a further depth of about 600 feet. There are also deposits of Permian rocks, red marls with grey breccias and sandstones, in Leicestershire, which reach a thickness of about 60 feet.

The Permian deposits are presented in their greatest development in eastern Devon. There the well-known red earth produced by the red marls, soft red sandstones, red conglomerates and breccia—intensified in the districts north of Torquay by the dark red Watcombe clays—are a most distinguishing feature of the products of Permian times. Altogether, these various strata attain a thickness of about 2,000 feet, covering a large area from Paignton northwards, through Torquay, Teignmouth, Dawlish and Exmouth, to Exeter, and thence to Tiverton; a narrow belt extends into Somerset to the Wiveliscombe area. From near Budleigh Salterton, in the east, to Crediton and

Hatherleigh, in the west, the county displays the rich red fields, red lanes and combes peculiar to these soft Permian strata.

In Scotland there is a small extension of the Cumbrian facies into Annandale, to Dumfries and to the Thornhill area of Nithsdale, where various beds of sandstones, breccias and conglomerates attain a thickness of over 1,000 feet; elsewhere the Permian rocks are not much in evidence, a small tract being near Mauchline in Ayrshire and others in the north, to the east of Elgin and near Cummingstone.

From this superficial survey we see how extensive were the Permian deposits over this country following the low-lying and tropical Carboniferous period. Bearing in mind the terrestrial and wind-formed character of the Lower Permian series, it is assumed that there was a general uplift of the land, a gradual decline of the tropical forests; coal seams are less frequent, and the soft yellow sands, devoid of fossils, came to be deposited over a large area of one-time Carboniferous regions. Thus the various strata of the Lower Permian terrestrial facies indicate that arid conditions gradually replaced the prolific vegetation of what is now southern Britain, the North Sea and Germany. The German extension of the Permian strata is known as "Dyas."

The Upper Permian reveals a subsequent submergence of much of the above area, when great beds of limestone were deposited in a sea which ultimately became land-locked, like the present-day Caspian. Desert conditions began to prevail around this shrinking sea. The thick bed of limestone has since become converted into dolomite or magnesian limestone by the magnesium salts dissolved in the saturated waters, which gradually evaporated into salt lakes. Fossils were, therefore, not plentiful, as these evaporating lakes came to resemble the Dead Sea. Eventually, the great beds of rock salt, which are found among the red marls and constitute such a valuable economic deposit in Germany, were formed, together with the extensive beds of anhydrite and gypsum. Then still more arid conditions occurred; the amphibians, which had once flourished on the sandy and muddy shores and left their footprints so plentifully behind them, now gave place to lizard-like reptiles, which roamed among the rank prairie grasses for their numerous insect prey. Thus what had in earlier Permian times been the great Germano-British inland sea had now become the great Germano-British desert, and, with the passing of the life of the period, the Palaeozoic era ended

Permian Flora and Fauna. The life of the Permian period indicates a great decline in old forms, which for hundreds of millions of years had flourished, and points to the dawn of a new age, the Mesozoic or Middle Life era. For instance, the last of the trilobites occur in the Permian of North America; the last of the *Orthoceratidae* also, and the *Goniatitidae* of the Upper Carboniferous. The flora of this period came to an end in the Permian.

The older types of fishes left few descendants. On the other hand, beyond the desert conditions which had supervened in the Germano-British area, there occurred throughout the world in Permian times a decided transition. The ammonites took the place of the goniatites; great tree-ferns developed, particularly *Caulopteris* and *Callipteris*; conifers became prolific, the yew-like *Walchia* flourishing in the drier conditions, together with the *Ullmannia*. The earliest types of cycads made their appearance in *Pterophyllum* and *Plagiozamites*. The araucarians, *Cordaites* and *Cordioxylon*, were in evidence, together with the remarkable ginkgo, which still survives. Thus we find vegetation beginning to approach modern types.

The Permian fauna exhibits this still more strikingly, for while labyrinthodonts flourished in the world-wide waters, together with the ganoid fishes such as *Platysomus* and the older molluscs, *Orthoceras*, *Nautilus* and *Cyrtoceras*, many of the reptiles were taking to the land as their permanent home, and the earliest known lizard appeared, the *Proterosaurus*. Thus was the first great advance achieved; the vertebrates began their never-ending war of destruction against the teeming invertebrates, the insect life which threatened to denude the world of land vegetation. Other singular reptiles were the *Cacops*, *Eryops* and the ground-lizard (*Edaphosaurus*), a creature about six feet in length. The *Cotylosaurus* is another much resembling present-day species. These terrestrial creatures were all lizard-like in build with straddling legs and powerful head-shields; some returned to the water periodically to lay their eggs and, tadpole-like, spent the earliest part of their existence there, but gradually they appear to have abandoned the water for breeding and adapted themselves to life in the grassy steppes or forests. These species at the close of the long Palaeozoic era (approaching a hundred million years ago) are the direct ancestors of the mammals which were soon to make their appearance, together with bird life, in the ensuing Mesozoic era.

LESSON 15

Deserts and Lakes of Triassic England

(See plate 52)

THE Triassic period is the first of the three great comprehensive divisions into which the long Mesozoic era, estimated to extend over nearly 100,000,000 years, is divided. The Mesozoic (middle-life) was a time of transition from the Palaeozoic or ancient-life era to the Cainozoic or recent-life era, and comprises three periods, the Triassic, Jurassic and Cretaceous. It was essentially the era of reptiles and amphibians, many species attaining enormous dimensions, whereas the Cainozoic, which covers the last 8 to 10 million years, is regarded as the era of mammals. The Mesozoic era is frequently referred to as the Secondary, according to a less satisfactory classification. It must be remembered that, while it is necessary for geological classification to regard these eras and periods as distinct, there were no breaks in geological time, the transition from period to period being gradual and continuous. Each *period*, however, is represented by a *system* of rocks or strata, the *system* being subdivided into different *series*, each bearing a distinctive name and representing a successive *epoch*.

The Triassic system of rocks in Britain is divided into the Bunter and Keuper series. The former attains a thickness of about 2,200 ft., and is composed of lower mottled sandstone, chiefly red, followed by pebble beds overlain by the upper mottled sandstone. Above this series is the more extensive Keuper series, which attains a maximum thickness of about 3,500 feet and is composed of sandstone and breccia at the base—with shales, sandstone, red marls, dolomitic limestones and conglomerate, together with extensive beds of rock salt above. The name "Trias" meaning "triple," was given by Von Alberti in 1834 owing to a threefold series being present in Germany, but it will be seen that one series is missing in this country. This is the Muschelkalk, a marine deposit between the Bunter and the Keuper series, composed of massive dolomitic limestone attaining a thickness of about 1,000 feet, containing abundant fossils of crinoids and, in particular, bivalve shells (in German "muscheln"), from which this series gets its name "Muschelkalk."

Over the Keuper is a thin transition bed of Rhaetic limestone, which is also generally regarded as Triassic.

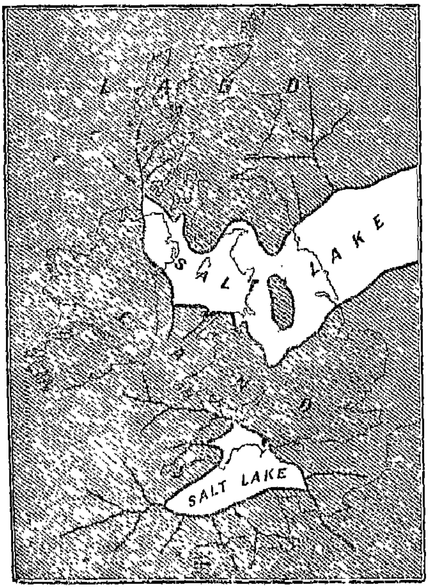
In Britain the Triassic beds approach the surface over the whole of Cheshire, over a large area of south and west Lancashire, nearly the whole of Nottinghamshire, and parts of Durham and Yorkshire, from near Hartlepool and Redcar southward almost to Ripon and York. They continue beneath the recent alluvium of the Ouse and Trent valleys to Nottinghamshire, where, throughout the western half of the county, the Bunter series approaches the surface. Nottingham Castle is built on a rock of the Bunter pebble beds Over a large area of the midlands from north Staffordshire, Derbyshire, Leicestershire and Warwickshire to Worcestershire and Gloucestershire, extend the Keuper beds of the upper Trias ; but below these are, over much of the area, the Bunter beds of the lower Trias. These latter approach the surface without the superimposed Keuper in west Cheshire, including Chester, and most of the Wirral, north Shropshire—where the Bunter pebble beds are chiefly in evidence—and also in the Manchester and Liverpool areas of south Lancashire. Northwards the Bunter facies extend to Furness and the Cumberland coastal area to St. Bees, where they attain a thickness of about 1,000 feet. Borings in the Isle of Man have also revealed their presence.

The Bunter cover a large area of the Vale of Eden, and although the Keuper series covers them in the Carlisle district, they extend into Scotland to the Dumfries district and form some isolated patches in Dumfriesshire and Ayrshire. An area of the Bunter bright red sandstone in the Isle of Arran reaches to about 1,000 feet in thickness elsewhere it is evident only in Elgin, to the west of Lossiemouth.

Throughout a large area of south-east England the Trias formations are known to extend below the superimposed strata of later deposits, borings having revealed the Keuper beds in Northamptonshire and Kent In Oxfordshire the Keuper series was found about 600 feet below the surface. Over a large area of Somerset and east Devon the bright red sandstone of the Bunter series may be studied conveniently, particularly along the cliff face between Sidmouth and Budleigh Salterton, where it presents a thickness of nearly 400 feet, resting upon about 80 feet of the Bunter pebble beds. These strata reappear in the Cherbourg area of France.

The red marls and sandstone of the Keuper may be well observed on the cliff-face between Axmouth, Seaton and Sidmouth, where they reach a thickness of nearly 1,400 feet. They are also present as red breccias and sandstones round the Quantock and Malvern hills, along the edge of Bridgwater Bay, east of Minehead, in the Bristol area, and in isolated patches across the Channel between Cardiff and Porthcawl In Ireland the Keuper is chiefly in the Belfast area, along the shores of the lough and in the valley of the Lagan, where Bunter is also observed. The two are also well presented in the Red Bay area of Cushendall and on the east side of Lough Foyle, while small patches occur in Tyrone and Londonderry.

Formation of Salt Lakes. At the beginning of Triassic times the districts mentioned above were mainly desert, resembling large areas of present-day central Asia; this is evidenced by the lower red and mottled sandstones of the Bunter series, which are obviously wind-blown desert sand. These desert conditions were a continuation of those of the Permian, but in course of time two saline lakes were formed (*see* accompanying map). The northern lake was far the larger and more saline; the southern lake covered much of the area of the previous Permian lake. They were fed by rivers which brought down large quantities of rolled pebbles, red sand and detritus, which deposited on the shores and lake beds material that went to



TRIASSIC BRITAIN. At the commencement of the Triassic period a large part of Britain was composed of desert. Then the land sank and two great salt lakes came into existence, which in turn gave place to desert conditions once more.

form the Bunter pebble beds The lakes subsequently shrank and vanished during the millions of years of Bunter times; then the Bunter bright red and mottled sands of the desert covered the pebble beds of the lakes

Later on, the Keuper epoch began with a general submergence, the sea from the south invading for a time a large portion of the low-lying desert and forming a great land-locked gulf, known to us as the Germano British gulf This gulf covered most of Germany, and resulted in the deposition of thick beds of limestone, known as the Muschelkalk, extending over Heligoland into the North Sea The British area, however, was too elevated for the Muschelkalk series to form Instead, shallows—represented by white sands, various coloured clays and pebbles—marked a shore line which gradually separated a large inland sea from the gulf This covered the whole of the midlands, what is now the Irish Sea, northern Ireland and the low-lying areas of the west of Scotland a narrow channel extended southwards across Devon to northern France The secular rise and fall of the land through the millions of years of the Keuper times produced the distinctive strata of this series and the varying shore-line of this inland sea A constant accretion of salt dissolved from the rocks and, permeating the growing bed of marl at the bottom, gradually reduced the sea to an intensely salt lake, in which thick beds of salt were deposited Thus the thickest beds of the Keuper series of red marls were formed, attaining in Cheshire a thickness of 3,000 feet, with beds of rock-salt as much as 100 feet thick, these also occur in north Yorkshire and Worcestershire, the salt deposits constituting a most valuable commercial product of this ancient Triassic salt-lake In later Keuper times the lake expanded as the result of a general submergence of the land, and a great land-locked sea took its place At this time, then, sea covered Germany, the Vosges and also Tirol—regions which constituted a wide strait to the great ocean stretching to the south-east The Alps and Vosges had not at that period come into existence

Triassic Flora and Fauna. The Triassic flora in the deposits of the salt-basins and desert areas is, of course, scarce, but elsewhere, on mountain slopes, the banks of rivers and in marshy regions, there existed sufficient flora to produce beds of shale and coal-seams containing fossil forms, while plants, tree stems and seeds were often brought down by floods becoming fossilized in

the lacustrine sediments. Conifers, resembling the cypress, were most abundant, together with *Albertia*, *Schizolepis* and *Baiera*. The cycads *Pterophyllum*, *Zamites*, *Podozamites* and *Otozamites* flourished; while the equisetums or horse-tail reeds were plentiful along river banks and marshy tracts. Some ferns flourished, such as *Anomopteris*, *Chelipteris*, *Lacopteris* and *Coniopteris*.

The Triassic fauna is of particular interest. The fishes, *Acrodus*, *Hybodus*, *Palaeoniscus*, *Gyrolepis*, *Pholidophorus*, and the ancient *Ceratodus* flourished. Cephalopods were plentiful in the Muschelkalk of Germany, including *Nautilus* and the Palaeozoic *Orthoceras*, together with the ammonite *Ceratites*; but many new genera and species of ammonites appear in this period, as *Phylloceras*, *Pinacoceras* and *Trachyceras*. The crinoid *Encrinus liliiformis* was most prolific, together with numerous genera of Lamellibranchs.

It is among the Reptilia that the most surprising development occurred Numerous types of giant lizards with mouths resembling those of turtles had now evolved. Some were tusked, like the *Dicynodon*; the *Hyperodapedon* and *Telerpeton* were found in the Keuper series, together with bones and teeth of labyrinthodons, whose footprints are also plentiful, both in the Keuper and Bunter deposits—indicating that they inhabited the shores of the lakes. The *Mastodonsaurus* and *Trematosaurus* also inhabited the sandy lake-shores of the Bunter epoch, but the millions of years which intervened between this and the later Keuper times saw an enormous development from these early types. The first true crocodiles appear. Strange creatures exhibiting close affinities to both amphibians and land reptiles were the Theriodonts, two of which are shown in Plate 52; from these creatures mammals may have descended. Plesiosaurs, reptiles which took to an entirely aquatic life and developed fin-like paddles instead of legs, made their first appearance in late Triassic times. Most important of all animal development was the appearance of the first mammal. This was a small marsupial type of creature, the *Microlestes*, which is believed to have resembled the *Ornithorhynchus* of Australia. But the age of great dinosaurs was at hand. The *Palaeosaurus*, *Teratosaurus* and *Thecodontosaurus* had already appeared, and at least 70,000,000 years were to pass before mammals were to dominate the world.

LESSON 16

Strata and Fauna of the Lias

(See plates 52 and 53)

THE Jurassic period is named after the Jura mountains between France and Switzerland, where its typical rocks are exceptionally developed The entire series are well represented in England, where they are divided into Lower Jurassic or Lias and Middle Jurassic, which with Upper Jurassic constitute Oolite These are further subdivided, according to the type of strata together with the successive epochs indicated by the species of fossils the Lias being divided into Upper Middle and Lower Lias, while the Oolite is divided into Upper Middle and Lower Oolite, containing between them seven sections These are discussed in our next Lesson

The name Lias was originally given by quarrymen to the hard limestones which were at the base of this series, subsequently it became applied to the whole facies These consist of the following beds Upper Lias, clays intercalated with thin beds of limestone, Middle Lias, beds of sandy clays, shales, and marlstone and Lower Lias, white and blue limestones alternating with shales and clays

The Lower Lias strata rest conformably upon the Rhaetic transition beds overlying the Trias They are well displayed along the cliffs of the Dorset coast from Lyme Regis to Bridport, attaining a thickness of about 500 feet They stretch across the width of England in a belt, as far as the Yorkshire coast, extending beneath Somerset, appearing at Watchet and in quarries near Ilminster, pass round the Mendip Hills and across the Bristol Channel, where they are well exposed in the cliffs between Penarth and Dunraven Castle. The Lower Lias beds have been found by borings in Gloucestershire, Oxon, and Warwickshire, to be about 450 feet thick, passing beneath east Leicestershire they attain a thickness of 700 feet in Lincolnshire, and through central Yorkshire to the coast between Redcar and Whitby, where they attain a thickness of over 700 feet Lower Lias deposits are present to the west of Carlisle and over a few isolated patches along the coast of Antrim In Scotland they are found in a few areas of Argyll, in Mull, and as far north

as Raasay and Broadford in Skye; while in Sutherland they occur beneath Dunrobin castle. These are but remnants that have survived denudation, their presence indicating roughly the extent of this northern inlet of the Liassic Sea.

Middle Lias. The Middle Lias beds consist chiefly of blue micaceous clays resting upon sandy clays and overlain by yellow sands, clays and a bed of ferruginous limestone which varies in thickness from about a foot in southern England to 150 feet in the Cleveland district of Yorkshire (where it is of great economic value) and also in the Midlands. The beds of the Middle Lias attain a thickness of about 350 feet in Dorset and may be seen to advantage in the cliffs between Charmouth and Bridport. Like the Lower Lias, these beds extend beneath Somerset, Gloucestershire and other areas, appearing more particularly at Glastonbury, Yeovil, Banbury, and the famous escarpment of Edge Hill. In these areas the valuable ferruginous limestone reaches about 25 feet in thickness. In south Lincolnshire, in the Grantham area, the Middle Lias attains considerable thickness; and then after thinning out beneath the Humber and Derwent area it thickens into the valuable outcrop of north Yorkshire. There the ferruginous deposit of "marlstone" or ironstone reaches a thickness of 150 feet and its proximity to the thick seams of coal in the adjoining districts has been a great source of wealth to this county. Only a small residue of the Middle Lias is found farther north—in the Inner Hebrides at Scalpa, Raasay, and Mull, where a few beds contain the characteristic Liassic fossils indicating the epoch.

The Upper Lias also extends from Dorset to the Yorkshire coast, where it may be easily studied at Whitby in particular. The beds are best developed, however, in Northamptonshire where, composed mainly of dark clay, they are nearly 160 feet thick, and in Yorkshire where, chiefly composed of blue shales and alum shales with overlying sands, they reach to 330 feet in thickness. They are also present in small areas above the Middle Lias in the Hebrides, attaining a maximum thickness of about 80 feet; and are in evidence more particularly at Northampton, Lincoln, Yeovil, and Ilminster, chiefly in quarries and cuttings where numerous fossils are present.

Secular Rise and Fall These Liassic deposits indicate that an extensive sea with low sandy shores, river estuaries and deltas, mud flats and the like, took the place of the arid salt-lake area

of Triassic times This was part of the process known as the secular rise and fall of large land areas relative to the sea level, which we see continuing through the long aeons of geological time down to the present age The lithosphere or rocky crust of the earth is relatively very thin, and continues to be subject to this ' bulging here and sinking there " over large areas Ages ago the lithosphere was thinner, and such movements were doubtless more pronounced

The rocks of the Jurassic period are evidence of such a subsidence wherever they occur Thus throughout central southern and the greater part of western Europe a general subsidence took place, Jurassic deposits of great thickness cover large areas both at and below the surface, the Lias series alone reaching to a thickness of over 2,000 feet in south-eastern France On the other hand, eastern Europe and the north Baltic regions were raised, and these, together with the mountainous areas of Britain and Scandinavia, were dry land largely covered with a rich vegetation and prolific fauna, to judge by the fossil remains which were washed down by floods or otherwise preserved Though, then, the Jurassic deposits generally represent areas that were submerged, they also incidentally contain relics of the land areas where, as a rule, no deposit was made and of which we would otherwise have no record

Evidence of this tilting of the land is very strikingly shown in the United States of America During Jurassic times, when the western districts sank gradually below the Jurassic sea and so came to be covered by a thick deposit of sediment and remains of marine organisms, reaching to 6 000 feet in thickness, the districts east of the Rockies went through a period of uplift which lasted throughout Jurassic times, and consequently we find there no appreciable deposits of this vast period—a period which may have lasted 20,000,000 years

In Britain, the Liassic probably covered a third or possibly nearly half of the Jurassic period, the submergence that at length converted the Keuper depression into an arm of the sea being very slow This inlet was not unlike the present Bay of Fundy and extended over the Inner Hebrides, the Firth of Clyde and most of Ulster Central, northern and southern England, except the Cornish area and the Thames valley, were beneath the sea and sinking deeper and deeper The Pennines, the Downs, the Chilterns, the Purbeck hills did not exist, neither did the

volcanic areas of Antrim, Mull, or Skye. The strata of the Liassic series, the clays, sand, and marls, are evidence of the gradual encroachment of the sea.

Fossil Remains. The life of the Liassic age has, therefore, been abundantly preserved in fossilized form under very favourable conditions, and is found to be totally different from much that existed at the close of the Palaeozoic era. The flora consisted largely of palm-like cycads, which were so prolific that the period is known botanically as the Age of Cycads. Equisetums were still plentiful, *Equisetum arenaceum* attaining an immense size. The ferns *Sphenopteris*, *Lacopteris* and many others flourished from Triassic times, as did the Ginkgo or maidenhair tree family. Conifers were abundant.

The fauna of these times was varied, prolific and very remarkable. The ammonites had developed into numerous very distinctive species characteristic of a particular zone of the Liassic deposits: the Lower Liassic characterized by *planorbis*, *bucklandi*, *oxynotus*, *jamesoni* and *capricornus*; the Middle Liassic by *margaritatus* and *spinatus*; the Upper Liassic by *serpentinus*, *communis* and *jurensis*.

Palaeozoic fishes had almost died out, their place being taken by numerous species of which *Dapedius*, *Acrodus* and *Hybodus* are in the Lower Lias, *Lepidotus* and *Leptolepis* in the Upper. The belemnites have become remarkably abundant, together with the lamellibranchs and gasteropods. The brachiopods *Cadomella* and *Spiriferina* were characteristic of the Lias, while *Rhynconella tetrahedra* and *Terebratula punctata* were prolific.

Insect life was also abundant, and there appeared the earliest flies, *Diptera*, together with the earliest known ants, *Hymenoptera*.

Reptilia made the greatest advance, for while the labyrinthodonts and anomodonts of earlier ages had disappeared, such creatures as the *Steneosaurus*, a carnivorous crocodile 18 feet long, had evolved. Most remarkable were the great fish-lizards, the *Ichthyosaurus* and *Plesiosaurus*. The ichthyosaurs existed in great numbers in the shallow Liassic seas and attained a length of as much as 30 feet, their bodies resembled whales except that the tail fins were upright, like those of fishes. They had acquired the mammalian function of bringing forth their young alive. The plesiosaurs were also great sea-reptiles, possessed of a long neck and small head with numerous teeth. They attained a length of about 14 feet and had paddles like the ichthyosaurs.

LESSON 17

Characteristics of the Oolite

(See plate 54)

The geological formations known collectively as Oolite (Gr. *oon*, egg; *lithos*, stone; the grains of calcite in the limestone characteristic of the formation resemble hard roe) represent the second and largest series of rocks of the Jurassic period and comprise the Middle and Upper Jurassic subdivisions.

The Oolite is divided into the following series:

Upper	Purbeckian.	
	Portlandian.	
	Kimmeridgian.	
Middle	Corallian and Ampthill Clays.	
	Oxfordian	Oxford Clay.
		Callovian.
Lower	Bathonian or Great Oolite.	
	Bajocian or Inferior Oolite.	

These series extend as an escarpment north and north-eastwards from Dorset to Yorkshire. Each division has, however, to be considered separately here, since the beds possess so much local differentiation, being largely composed of various clays intercalated with beds of limestone, sands and sandstone.

The Lower Oolite deposits extend from Dorset and Wiltshire, through Oxfordshire, Northamptonshire and Lincolnshire, to the north of Yorkshire. In the south-west they consist chiefly of limestones overlying sands, indicating that a shallow sea covered this area, but clays deposited farther north bespeak estuarine conditions.

The Inferior Oolite is also known as Bajocian, from Bayeux in France, where it is well developed. It includes the subdivision Aalenian. In England it is well presented from Bridport to Burton Bradstock, and around the Yeovil, Bath, Sherborne, Dundry and Cotswold hills areas. Though the limestone beds are thin in the Dorset and Wiltshire areas, being between 10 and 21 feet thick, the beds, with freestones and ragstones, attain a thickness of between 100 and 250 feet in the Bath area and

east of the Cotswolds From the Oxfordshire area to Northamptonshire the Inferior Oolite is composed chiefly of sands and ironstone, reaching in places to about 60 feet thick In Lincolnshire, the limestones form the famous cliff escarpment as much as 150 feet thick It is sandy in places and extends to the alternating limestone and estuarine sandstones and shales of north Yorkshire, which attain a thickness of about 400 feet and may be seen well exposed in the Robin Hood's Bay district and the Blea Wyke area. Elsewhere, this formation is only present in Skye, Raasay, Eigg, Muck, and a few small patches, including the Great Oolite, on the coast of Sutherland and Elgin. Its thickness reaches 300 feet in the Jura area and nearly 1,000 feet in Provence

Great Oolite Series. The Great Oolite or Bathonian (named from Bath, where it is well exposed) extends from Dorset to Yorkshire, adjoining and covering much of the Inferior Oolite. Its various strata attain a thickness of about 250 feet in Dorset and the Bath area, dwindling to about 140 feet in Oxfordshire and 100 feet in Lincolnshire. The Great Oolite is very fossiliferous, and may be studied to advantage at Bath, Minchinhampton, Stonesfield, Northampton, Bedford, Lincoln and Gristhorpe Bay on the Yorkshire coast

The Great Oolite includes the Cornbrash, Forest Marble, Stonesfield Slate and Fuller's Earth formations

The Cornbrash consists of a very friable earthy limestone which covers the Great Oolite to a depth of between 5 and 40 feet over its entire area from near Weymouth to the Yorkshire coast *It is, therefore, very extensive, and is conducive to the* raising of fine corn crops owing to its friable or *brashy* texture.

The Forest Marble derives its name from Wychwood forest, where it is extensively quarried. It is nearly a hundred feet thick in Dorset and extends from there to the above area and into Buckinghamshire, where it thins out and the white marly limestone, the so-called " marble," gives place to a thin belt of clay. Thus there is evidence that the shallow sea here became an estuary or delta

The Fuller's Earth or Fullonian formation is below the Forest Marble, and extends from Dorset to Bath, Stroud and Cheltenham, attaining a thickness of from 7 to 150 feet It does not extend farther north than Oxfordshire Fuller's earth consists of marly clays with bands of soft limestone ; the more refined

varieties of the earth, chiefly found in the Bath area, have a considerable commercial value, particularly for fulling cloth.

The Stonesfield Slate formation, which is at the base of the Great Oolite series, chiefly in Gloucestershire and Oxfordshire, is named from Stonesfield, where it has long been quarried. It consists of thin flaggy beds of sandy limestones, shales and laminated micaceous sandstones, attaining a thickness of about 30 feet in Oxfordshire. These beds are remarkable for the great number of fossils they contain, among them remains of the marsupial mammals *Phascolotherium* and *Stereognathus*, land plants and insects in profusion, and the reptiles *Plesiosaurus*, *Cetiosaurus*, *Megalosaurus*, and *Teleosaurus*. The fishes *Hybodus*, *Ganodus* and *Ceratodus* are also prolific, and there is evidence of the first bird, *Archaeopteryx*.

The Great or Bath Oolite itself is a bed of limestone reaching to 100 feet thick between Bath and Minchinhampton, and extending from this area to Bradford-on-Avon, Northampton, Bedford, and Lincolnshire, where it gradually thins out. It constitutes the famous freestone known as Bath-stone, and is much quarried in the Bath and Minchinhampton area. This deposit is rich in fossils similar to those found in the Stonesfield Slate.

The Middle Oolite is divided into Oxfordian below and Corallian above, the Oxfordian presenting two formations, the lower being the Callovian and the upper the Oxford Clay.

The Callovian or Kellaways Rock named from the village of Kellaways in Wiltshire, varies in thickness from a few feet to 80 feet, and extends from Dorset to Yorkshire, reappearing in Skye. It consists of the calcareous sandstone from which it gets its name. It is rich in fossils, over 200 species of fish being found in it, together with numerous *Ammonites calloviensis*. *Ammonites modiolaris* and belemnites. This formation is well exposed at Weymouth, various places in Wiltshire and Oxfordshire, St. Neots, Hackness in Yorkshire, and Uig in Skye.

The Oxford Clay above the Callovian consists of stiff blue and brown clays with septarian nodules and bituminous shales. They vary in thickness from 170 to 600 feet, extending from Dorset to Scarborough. This formation indicates a muddy deposit, estuarine probably, in which Lamellibranchs, *Ammonites Jason* and belemnites were abundant, judging by their fossil remains. Plesiosaurs, ichthyosaurs, megalosaurs, crustaceans and insects also flourished.

The Corallian indicates the changed conditions of the succeeding age. This formation lies above the Oxford Clay, and is so named because of the masses of reef-building coral existing in its shelly limestone beds, which indicate that it was part of a vast coral reef and that clear tropical seas existed where it is found. This is in Dorset, where it reaches a thickness of about 200 feet, extending northwards through Wiltshire and Oxfordshire. There are also valuable beds of ironstone in Wiltshire. In Buckinghamshire, Bedfordshire, Huntingdonshire and Lincolnshire the coral limestone is replaced by the Ampthill Clay beds, which are evidence of the river delta or estuary which persisted through these Middle Jurassic times.

A prolific fauna flourished. In the limestone, in addition to the coral, sea-urchins and the abundant *Ammonites perarmatus* and *Ammonites plicatilis*, were the reptilia mentioned above. The rocks with the numerous fossils are well exposed in the cliffs south of Weymouth, at Steeple Ashton, Calne, the Abingdon area, Oxford, Upware in Cambridgeshire, and at Filey, Malton, Scarborough, and the Vale of Pickering, where the beds attain a thickness of 400 feet. They also appear at Clyne Hill in Sutherland.

The lowest of the Upper Oolite series is the Kimmeridgian, which consists of dark grey, shaly clays with occasionally septarian nodules and bands of limestone. They attain a thickness of 1,000 feet at Kimmeridge Bay in Dorset where they are well exposed; this dwindles to about 300 feet in Wiltshire and to less than 100 in Berkshire, Oxfordshire and Buckinghamshire. After passing through Cambridgeshire, they thicken in Lincolnshire to 600 feet. In Yorkshire, the series is not much exposed, except at Speeton Gap, on the coast, and the Vale of Pickering.

The strata indicate a muddy and shallow sea or estuary, in which Lamellibranchs and Cephalopods were numerous, and corals and echinoderms rare; while the ichthyosaurus flourished in the sea, two species of pterosaurs or pterodactyls in the air, and plesiosaurs, pliosaurs, cetiosaurs, megalosaurs, the gigantosaurus and iguanodon roamed the wide low-lying areas, shallow waters, and marshy stretches which covered so much of south-east England in those days of at least 50 million years ago.

Portland and Purbeck Formations, The Portlandian formation, named after the Isle of Portland, where it is well developed,

CREATORS OF REALISTIC ROMANCE. Left, Daniel Defoe (c. 1659-1731) was born in London, the son of a butcher. Educated for the Nonconformist ministry, he founded a congregation at Tooting, became a hose factor, managed a brick and tile works, and acted as a Government agent. He lies buried in Bunhill Fields. Right, Jonathan Swift (1667-1745), who was born in Dublin, served Sir William Temple as secretary, engaged in much political controversy and in 1713 was made Dean of St. Patrick's, Dublin. His friendships with Stella (Esther Johnson) and Vanessa (Esther Vanhomrigh) are among the most memorable in literary history. He died insane and was buried in St. Patrick's, Dublin. ENGLISH LITERATURE 31

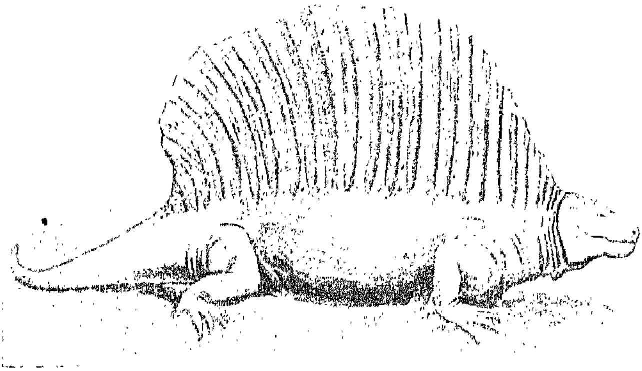
PERFECTERS OF THE ESSAY. Left, Sir Richard Steele (1672-1729), who was born in Dublin, held a commission in the army and in 1707 was appointed gazetteer to the Government. In 1709 he launched "The Tatler," succeeded (1711-1712) by "The Spectator" and by many other yet shorter-lived periodicals. Right, Steele's life-long friend, Joseph Addison (1672-1719)—scholar, poet, playwright, member of Parliament and Irish Chief Secretary, but, above all, collaborator with Steele on "The Tatler" and "The Spectator." He was buried in Westminster Abbey. ENGLISH LITERATURE 31

SAMUEL JOHNSON (1709–1784). Born at Lichfield, the son of a bookseller, he went to London in 1737 and earned a precarious livelihood with his pen. In 1762 he received a pension from the government, and in his later years he was recognized as the king of English letters.
Portrait by Sir J. Reynolds, National Portrait Gallery

HORACE WALPOLE (1717–97). Fourth son of Sir Robert Walpole, he was M.P. for twenty-six years, but his main interests were literary. He settled at Strawberry Hill, Twickenham, in 1747, and converted his villa into a world-famous museum of furniture, pictures and curios.
Portrait by N. Hone, National Portrait Gallery

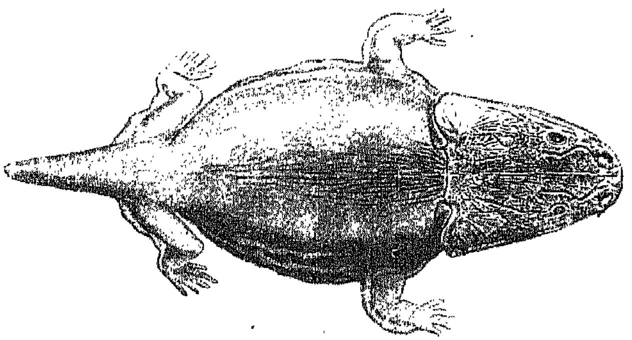
EDMUND BURKE (1729–97). Born in Dublin, he entered Parliament as a Whig in 1765, and strongly advocated a conciliatory attitude towards the American colonies. The French Revolution converted him into a reactionary.
Portrait by Sir J. Reynolds, National Portrait Gallery

EDWARD GIBBON (1737–94). Born at Putney, he travelled and wrote on miscellaneous literary topics until 1772, when he began his life-work, the "History of the Decline and Fall of the Roman Empire," published 1776–1788.
Portrait by Henry Walton, National Portrait Gallery



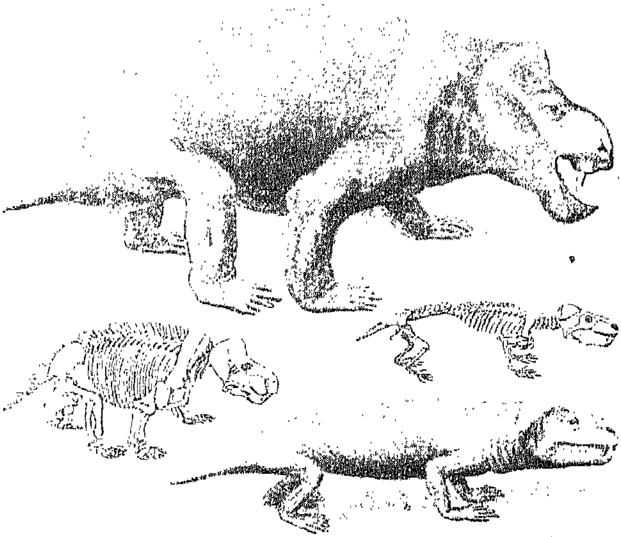
REPTILE OF THE PERMIAN. This reconstruction shows a ground lizard (Edaphosaurus), six feet long with apparently useless spiny protuberances along its backbone. One of the earliest types of true reptile, it soon became extinct. GEOLOGY 14

Reconstruction after Cave



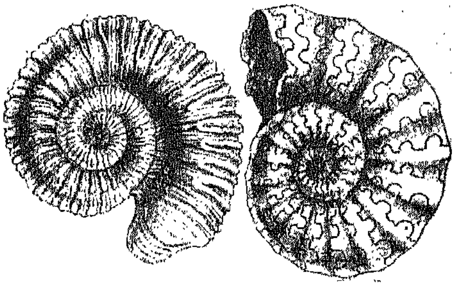
GROTESQUE RIVAL OF THE REPTILES. During the Permian period the supremacy of reptiles became so pronounced that certain terrestrial amphibians went back to the water again, gradually extending the length of their larval life in water until they became completely aquatic. In effect they remained in the tadpole stage of their existence. The weird creature that resulted is shown by this reconstruction of Metoposaurus ("face lizard"). GEOLOGY 14

Reconstruction after Fraas



TYPICAL THERIODONTS. Kannemeyeria (above) and Cynognathus ("dog-jaw") are representative of the Theriodontia—reptiles that closely resembled both amphibians and mammals and from which mammals may have descended. GEOLOGY 15

Kannemeyeria reconstruction by Prof. D. M. S. Watson, F.R.S., and Cynognathus after H. S. Pearson



AMMONITES. During the Liassic period ammonites—two of which are pictured above—were so varied and abundant that they serve to identify the successive strata. GEOLOGY 16

followed as a consequence of another subsidence of the land. Thick beds of limestone and calcareous freestone were laid down in the course of many thousands of years, until layers approaching 300 feet thick were formed. These are well seen in the cliffs from Durlstone Head to St. Alban's Head in Dorset; other facies appear at Upwey near Weymouth, at Tisbury in the Vale of Wardour, and at Swindon, where the formation has dwindled to about 100 feet thick It extends to Oxford, Thame and Aylesbury, but does not appear farther north than Buckinghamshire, though the beds extend a long way south, and reappear at Boulogne in France. The enormous *Ammonites giganteus*, like a cart-wheel, flourished then, and the coral *Isastraea oblonga*, together with the tropical marine fauna of late Jurassic times already mentioned. This Portland stone is of considerable commercial value for building, more particularly the oolitic freestone.

The Purbeckian formation, named from the Isle of Purbeck, occupies most of this area and is well exposed. It overlies the Portlandian with freshwater limestones followed by layers of ancient earth—the so-called "dirt-beds"—in which the fossilized stems and roots of Jurassic cycads and conifers have been found *in situ*. These beds are overlain by a marine deposit in which oyster and other fossil shells figure largely, such as may be seen exposed at Durlstone Bay near Swanage, where the strata are 400 feet thick. It diminishes westward to Worbarrow Bay and Lulworth Cove, where it is under 200 feet thick. The Purbeckian appears also near Swindon, in the Vale of Wardour, and at various localities and cuttings in Oxfordshire and Bucks, notably at Thame and Aylesbury. The beds come near the surface in parts of Sussex and Kent, while actually protruding near Battle. The fossil fauna of this formation is largely freshwater and estuarine, in which crocodiles and turtles figure with numerous fishes and the marsupials *Spalacotherium, Plagiaulax* and *Triconodon*. Insects were also prolific among the cycads and conifers. But this last marine deposit indicates the beginning of the great subsidence of the land that heralded the following Cretaceous period. The well-known Purbeck marble, composed mainly of masses of shells of *Paludina* and found at Swanage, marks the end of the long Jurassic period.

Our Course in Geology is continued in Volume 5.

LESSON 15

Important Points about Prepositions

We now come to the prepositions and the cases they govern, a very important matter in German. As there are different forms for the different cases of articles, nouns, adjectives and pronouns, the cases which the prepositions govern must be clearly remembered. A good way of doing this is to remember an example in which the preposition occurs. It is more important to learn *durch die Tür, durch das Haus* (through the door, through the house) than to learn that *durch* takes the accusative. After all, the former way is the way in which Germans learn it, and it is the more natural and satisfactory way.

Prepositions governing the Accusative. These are: *durch* (through, by means of), *für* (for), *gegen* (against, towards), *ohne* (without), *um* (round, about), *wider* (against; not to be confused with *wieder* again). The preposition *sonder* (without) is now archaic and rarely met with in modern German.

Examples: *durch die Strasse* (through the street); *durch ihn* (by means of him); *für das Geld* (for the money); *für sie* (for her); *gegen den Feind* (against the enemy); *gegen zehn Uhr* (towards ten o'clock); *ohne das Kind* (without the child); *ohne die Uhr* (without the clock); *um die Stadt* (round the town); *um zehn Uhr* (round about ten o'clock); *wider das Recht* (against the law); *wider den Strich* (against the grain).

Prepositions which govern the Dative. These are: *aus* (out, out of), *ausser* (except, besides), *bei* (near, at), *binnen* (within), *entgegen* (towards, against), *gegenüber* (opposite, towards), *gemäss* (according to), *mit* (with), *nach* (after, to, according to), *nebst* (besides, together with), *sam(m)t* (besides, together with), *seit* (since), *von* (of, from), *zu* (to, at).

Examples: *aus den Augen, aus dem Sinn* (out of sight, out of mind); *ausser ihm* (apart from him); *ausser dem Lohne* (besides the reward); *bei der Ecke* (at, near the corner); *bei der Kirche* (at, near the church); *binnen einer Stunde* (within one hour); *binnen zwei Wochen* (within two weeks); it should be noted that *binnen* is only usual with expressions of time; *entgegen der*

Verabredung (against the arrangement); *entgegen der Stadt* (towards the town); *gegenüber dem Hause* or *dem Hause gegenüber* (opposite the house). *ihm gegenüber* (towards him, with regard to him) (note that when used in this second sense it is customary to place the preposition after the noun which it qualifies, when used in the first sense the preposition can come either before or after); *gemass den Regeln* or *den Regeln gemäss* (according to the rules); *mit dem Schiffe* (with the boat, by boat), *mit der Eisenbahn* (by railway), *nach dem Hafen* (to the harbour); *nach meiner Meinung* or *meiner Meinung nach* (according to my opinion) (note that in the second sense it is more usual to place the preposition after the noun); *nebst Bohnen* (together with beans) (in the sense of "besides" *nebst* is archaic nowadays; in the sense of "together with" it is mostly found without article); *samt den Leuten* or *sammt den Leuten* (together with the people) (it should be noted that *sam(m)t* also is not used much in the sense of "besides"); *seit meiner Abfahrt* (since my departure); *seit einer Stunde* (since an hour ago), *von dem Manne* (from, by the man); *der König von England* (the king of England) *zu jener Zeit* (at that time); *zu der Frau* (to the woman).

Prepositions governing Accusative and Dative. These are: *an* (at, on), *auf* (on, upon), *hinter* (behind), *in* (in, into), *neben* (next to, near), *über* (over, concerning), *unter* (under, among), *vor* (before), *zwischen* (between). At this stage only the general rule need be remembered; that these prepositions govern the accusative when motion is implied, and the dative when rest, or motion in a restricted place, is implied. This rule works well with ordinary verbs of motion, but it is frequently difficult to apply when verbs are used in a transferred sense or when no motion or rest is possible.

Examples: *er steht an der Tür* (he stands at the door); *er geht an die Tür* (he goes to the door); *er springt auf dem Schiff* (he is jumping about on board the boat); *er springt auf das Schiff* (he jumps on to the boat), *er steht hinter der Tür* (he stands behind the door); *er geht hinter die Tür* (he goes behind the door); *er liegt in dem Wasser* (he is lying in the water); *er fällt in das Wasser* (he falls into the water); *der Hund lief neben seinem Herrn* (the dog was running along next to his master); *der Hund lief neben seinen Herrn* (the dog ran up to the side of his master); *der Vogel schwebte über dem Wasser* (the bird hovered over the water); *der Vogel flog über das Wasser* (the bird flew across the water);

der Mann lag unter dem Tische (the man lay under the table); *der Mann fiel unter den Tisch* (the man fell under the table); *er stand vor dem Bilde* (he stood before the picture), *er lief vor den Richter* (he ran before (up to) the judge), *sie stand zwischen den beiden Männern* (she stood between the two men), *sie lief zwischen die beiden Männer* (she ran between the two men).

In all these examples students will have noticed that the case to be used is quite obvious. Frequently we can reproduce the sense in English by using "on" (dative) and "on to" (accusative) or "in" (dative) and "into" (accusative). For further use of these prepositions see later Lessons in this Course.

A complete list of prepositions governing the genitive cannot be given, and it would not be particularly useful if it could. Nouns are constantly taking on the functions of a preposition followed by the genitive, and it is frequently difficult to decide whether one is dealing with a preposition or not. (Compare the English use of "by means of," "for the sake of," which could be described as prepositions taking the genitive, and "in addition to," "in answer to," as prepositions taking the dative.)

Prepositions governing the Genitive. The following are the most common: *diesseit* (this side of), *jenseit* (that side of), *statt, anstatt* (instead of), *trotz* (in spite of), *während* (during), *wegen* (on account of).

Examples. *diesseit des Flusses* (this side of the river), *jenseit der Grenze* (on the other side of the frontier); *statt meiner Mutter* (instead of my mother), *trotz des schlechten Wetters* (in spite of the bad weather), *während der Ferien* (during the holidays); *wegen der grossen Hitze* (on account of the great heat).

Notice that *um willen* (for the sake of) takes the genitive, and that *um* comes before, *willen* after the word qualified: *um des lieben Friedens willen* (for the sake of dear peace, i.e. for the sake of peace at any price).

EXERCISES.

In order to become familiar as soon as possible with the usage of these prepositions, fill in the requisite endings in the following:

(1) Accusative. *Durch d... Stadt, d... Mann, d... Kind, d... Zeitung, d... Freund, d... Haus* (Remember that *Stadt* and *Zeitung* are feminine, *Mann* and *Freund* masculine, *Kind* and *Haus* neuter). Write out the same examples, using the prepositions, *für, gegen, ohne, um, wider*.

(2) Dative. *Aus d... Garten, d... Bett, d... Schiff, d... Buch, d... Küche, d.... Schule* (*Garten* is masculine, *Bett, Schiff Buch* are neuter, *Küche* and *Schule* are feminine) Write out the same examples using the prepositions *mit, von, zu*

(3) Genitive. *Während d... schön... Wetter... fahre ich jeden Sonnabend auf d... Land...* (during the fine weather I go to the country every Saturday); *wegen d... unsicher.. Lage bleiben wir diesen Sommer in England* (on account of the uncertain position we are staying in England this summer), *trotz d... hoh... Preise wird viel verkauft* (in spite of the high prices much is sold); *er versprach, um d... Mutter willen zuhause zu bleiben* (he promised to stay at home for the sake of his mother).

LESSON 16

The Structure of Sentences

We are now familiar with most of the forms that German words can have, and we have even, occasionally, learnt which forms are to be employed in certain cases. In this Lesson we arrive at construction—the way words are put together in order to make German sentences It will be convenient if we start out with very simple sentences.

The simplest form is the one-word statement "*Feuer!*" yelled out will be as readily understood and reacted to as the English "Fire!" In such simple statements the question of word-order naturally cannot arise Some grammarians would not agree that "fire" is a sentence at all, and they would not call anything a sentence unless it contained a subject and a predicate; the words "has broken out" or "has started" are understood.

Simple sentences with a subject plus predicate are treated in German as in English: *er kommt*, he comes, *sie gehen*, they go; *das Haus brennt*, the house burns; *das Kind schreit*, the child screams. In the question form the German type is simpler, as there is no need for a circumlocutory phrase. *Kommt er?* Does

burning; *das Kind schreit nicht*, the child is not screaming. The negative question form in a simple sentence is as follows: *Kommt er nicht?* Is he not coming? *Gehen sie nicht?* Are they not going? *Brennt das Haus nicht?* Is the house not burning? *Schreit das Kind nicht?* Is the child not screaming?

For practice in construction translate into German: did he go? he worked; she did not come; did not the father speak? (*sprechen*, to speak, *der Vater*, father); does the wind blow? (*der Wind*, wind; *blasen*, to blow).

This simple type of sentence can be readily expanded without altering the construction; for instance, by supplying a qualifying adjective to the noun: *Das neue Haus brennt*, the new house is burning. *Brennt das neue Haus?* Is the new house burning? *Das neue Haus brennt nicht*, the new house is not burning. *Brennt das neue Haus nicht?* Is the new house not burning? *Das kleine Kind schreit*, the small child is screaming. *Schreit das kleine Kind?* Is the small child screaming? *Das kleine Kind schreit nicht*, the small child is not screaming. *Schreit das kleine Kind nicht?* Is not the small child screaming?

The verb of the sentence can be qualified by an adverb. This adverb is placed behind the verb: *das kleine Kind schreit laut*, the small child screams loudly. If we turn this sentence into a question, the word *laut* remains at the end of the sentence just as it does in English. We merely interchange the position of subject and verb, and leave the adverb alone: *Schreit das kleine Kind laut?* Does the small child scream loudly? In a negative statement, the position of the adverb is also not affected: *das kleine Kind schreit nicht laut*, the small child does not scream loudly. If we turned this negative statement into a question, the position of *nicht laut* would again not be affected: *Schreit das kleine Kind nicht laut?* Does not the small child scream loudly? *Blies der starke Wind nicht laut?* Did not the strong wind blow loudly? *Sprach der wütende Vater nicht laut?* Did not the angry father speak loudly?

Another type of sentence has subject, predicate and direct object. Here, again, the German order does not differ from the English: *er las das Buch*, he read the book; *das kleine Kind las das gute Buch*, the small child read the good book; *der wütende Vater schlug den unartigen Sohn*, the angry father hit the naughty son. If we turn such a statement into a question we merely interchange the order of subject and verb and leave the

direct object at the end just as we did the adverb: *Las das kleine Kind das gute Buch?* Did the small child read the good book? *Schlug der wütende Vater den unartigen Sohn?* Did the angry father hit the naughty son? If we negative the statement, it is most usual to put the negative particle at the end *das kleine Kind las das gute Buch nicht*, the small child did not read the good book. This is the correct order, though very frequently one finds: *das kleine Kind las nicht das gute Buch.* This last statement ought to mean, " the small child did not read the good book, but it read something else," since the *nicht* when placed in that position, ought to give special negative stress to the word before which it appears. But in modern German few people bother about such niceties.

When we have subject plus predicate plus direct object plus indirect object, the direct object comes before the indirect object: *er las das Buch in dem Zimmer*, he read the book in the room; *er gab es ihm*, he gave it to him In such sentences, however, the adverb would come in the same position as if there were no indirect object: *er las das Buch laut in dem Zimmer*, he read the book loudly in the room. If the indirect object is a pronoun, the adverb comes last: *er gab es ihm widerwillig*, he gave it to him grudgingly. An adverb of time comes before an indirect object or a complement: *er las das Buch gestern in dem Zimmer*, he read the book yesterday in the room. This is perfectly correct, though it is more usual to place the expression of time at the beginning of the sentence.

Inversion in Simple Statements. If anything precedes the subject and the verb, then the verb comes before the subject. This usage also occurs in English, though to a much more limited extent, and then it is optional. For instance: " Yes," replied the man, " I am coming." This inversion is a very important matter in German, as it occurs in almost every other sentence. Thus the sentence, *er las das Buch gestern in dem Zimmer*, would usually begin with *gestern*, and then it would have to run: *gestern las er das Buch in dem Zimmer*. The expression which is placed at the beginning of the sentence should really be emphatic. But as we qualify most of our statements by some reference to time, time expressions have lost their emphatic nature, and the fact that an expression of time begins the sentence does not necessarily mean that there is any special emphasis on the time. If, however, we were to say, *in dem Zimmer las er*

gestern das Buch, this would mean that he was reading the book yesterday in *this* room (we should then have to put a stronger accent on the *dem*), or it means that he read it in the room and not in the scullery or the garden. Similarly, the sentence, *das Buch las er gestern in dem Zimmer*, must either stress *das*, making it demonstrative, or it must mean book as against journal, magazine, newspaper.

Note that in such a sentence the position of the *nicht* will also alter the sense of the sentence : *gestern las er nicht das Buch in dem Zimmer*, yesterday he was not reading the book in the room ; *nicht gestern las er das Buch in dem Zimmer*, it was not yesterday that he was reading the book in the room (but some other time, if at all). Similarly, there is a difference between the following two statements : *in dem Zimmer las er das Buch gestern nicht*, and *nicht in dem Zimmer las er gestern das Buch*.

LESSON 17

Position of the Verb

LESSON 16 began with a consideration of the simple direct clause. We return to that later on, but in this Lesson we deal with the direct clause in which a compound tense of a verb is used instead of a simple tense In a direct clause which introduces a compound tense, the auxiliary occupies the ordinary position of the verb, and the rest of the verb goes to the end of the sentence, as in the following examples :

Er hat ihn gesehen : he has seen him. *Er hat ihn gestern gesehen* : he has seen him yesterday. *Er hat ihn gestern auf der Strasse gesehen* : he has seen him yesterday on the street. *Der Mann wird morgen kommen* : the man will come tomorrow. *Der Mann wird morgen mit der Butter kommen* : the man will come tomorrow with the butter. *Der Mann wird morgen mit der Butter in die Stadt kommen* : the man will come into the town with the butter tomorrow. *Sie wird es getan haben* : she will have done it. *Sie wird es gestern getan haben* : she will have done it yesterday. *Sie wird es gestern auf ihrem Wege durch die Stadt getan haben* : she will have done it yesterday on her way through the town.

Inversion does not affect the position of the main verb. It is the auxiliary which changes position with the subject: the rest of the sentence is unaffected. For instance: *Gestern wird sie es auf ihrem Wege durch die Stadt getan haben.* In case of special emphasis it is even possible to transpose the past participle to the beginning of the sentence. *Er hat den Mann gesehen*: he has seen the man; but when the emphasis is on the seeing, *gesehen hat er den Mann* he has *seen* the man

Negation and question make little difference to the order of the sentences *Sie wird es nicht gestern getan haben* *Wird sie es gestern nicht getan haben?* It should be noted that the different position of the *nicht* in these two sentences is not a very important matter: they might just as well have been the other way round for all the difference it makes to most speakers of modern German: *Wird sie es nicht gestern getan haben?* Thus, whatever may happen to the main part of the sentence, the verb at the end remains completely unaffected.

Usage of Separable Verbs. In Lesson 14 (Volume 3, page 444) we have dealt with the forms of the so-called separable verbs. We now come to the usage. In a principal (direct) clause, the separable particle goes to the end of the sentence. *Zusehen*: to watch. I watched him: *Ich sah ihm zu.* I watched him yesterday: *Ich sah ihm gestern zu.* I watched him working yesterday: *Ich sah ihm gestern bei der Arbeit zu.* I watched him working yesterday in the garden: *Ich sah ihm gestern bei der Arbeit in dem Garten zu.* We see, then, that the separable particle normally comes at the end of a principal clause, whatever may intervene, and however long the intervention may be. It is, therefore, essential to read right through a German sentence before coming to any conclusion about the meaning.

Separable verbs are of frequent occurrence, and usually they radically alter the meaning of the simple verb. Thus in the following sentences:

Er schreibt das Diktat von seinem Nachbar in der Klasse ab: he copies the dictation from his neighbour in the class Before we get to the little particle *ab*, we do not know that he is copying at all. In English the verbal idea is clear from the moment we have heard or read the verb; in German we must wait until the end of the sentence to discover the particle, if any. A few more examples are:

Er fiel vor zwei Wochen in dem Examen durch (*durchfallen*, to fail):

he failed two weeks ago in the examination *Sie fiel wegen ihrer grossen Schönheit in der Gesellschaft auf* (*auffallen*, to attract notice, attention) she was noticed in society on account of her great beauty *Das Schiff ging auf seiner Reise nach Südamerika in einem grossen Sturme unter* (*untergehen*, to sink) on its voyage to South America the ship sank in a great storm *Die Sonne geht um halb sechs auf* the sun rises at 5 30 *Die Sonne geht um halb sechs unter* the sun sets at 5 30 (In the last two sentences it is impossible apart perhaps from the general context, to tell whether the speaker is referring to the rising or the setting of the sun until the particle is known at the end of the sentence)

As explained in Lesson 14, the separation only takes place in the present and past tenses In the past participle the prefix is again joined with the verb Examples *Ihrer grossen Schönheit wegen ist sie in der Gesellschaft aufgefallen* *Auf seiner Reise nach Südamerika ist das Schiff in einem grossen Sturme untergegangen* *Die Sonne ist um halb sechs aufgegangen* *Um halb sechs ist die Sonne untergegangen*

After the following words inversion is not used. *aber* (yet, however, but), *allein* (however, but), *doch* (yet, however), *jedoch* (yet. however), *oder* (or), *und* (and) *Zuerst wollte er nicht kommen, aber er kam doch* at first he did not wish to come but he came in the end In this sentence we could substitute *allein* or *doch*, though *doch* would be awkward on account of the *doch* at the end. *Hände hoch, oder ich schiesse* hands up or I shoot *Er machte die Tür zu, und ich ging weg* he closed the door and I went away

Frequently, especially in commercial German, there is inversion after *und* *Wir sind im Besitze Ihres Briefes, und hoffen wir*, etc : we are in receipt of your letter, and we hope, etc. This usage is frowned upon by all German grammarians *Auch* (also) is used with different meaning when it causes inversion *Auch er sagte* he, too, said—or, even he said, but *auch sagte er*: moreover he said

When two of these little words occur together at the beginning of a sentence inversion does not take place if they are both used as unstressed conjunctions *Und auch er sagte* and he also said. But in the sentence, *Und doch sagte er* (and yet he said), there is inversion, because in such a sentence the *doch* would be stressed more than usual, and would really be an adverb. As soon as another word occurs in the beginning together with any of these conjunctions inversion has to take place. Thus we should

say: *und er kam gestern*: and he came yesterday; or *und gestern kam er* *Aber der Richter wollte ihn nicht entlassen* but the judge would not release him, or *aber ihn wollte der Richter nicht entlassen* (In the second case, the *ihn*, being in an unusual position, is, moreover, stressed The implication is that the judge was willing to release somebody else, but he would not release *him*.)

Order of Adverbial Expressions. In many grammars, a rule is given that, in German, adverbial expressions are arranged in the following order: time, manner, place This is an important rule, as long as one does not expect it to work in every sentence. If we look back to the example, *der Mann wird morgen mit der Butter in die Stadt kommen*, we see that *morgen* is the time-expression, *mit der Butter* is the expression of the manner in which he is coming, *in die Stadt* gives the place-reference, so that the sentence satisfies the regulations in the grammars. It would be equally correct, however, though no doubt a little unusual, to say: *der Mann wird mit der Butter morgen in die Stadt kommen.* But much the most usual practice will be to place the idea of time first, and invert subject and verb: *Morgen wird der Mann mit der Butter in die Stadt kommen.* The position of *in die Stadt* however, is fixed, and the reason why it is fixed we discuss in the next Lesson

Turn the following narrative into the perfect tense:

Sie schrieb mir einen Brief Ich antwortete. Dann traf ich sie gestern auf der Strasse, und sie erzählte mir von dem Tode ihres Onkels. Der Onkel ging neulich spazieren. Ohne grosse Vorsicht ging er über die Hauptstrasse. Ein Auto überfuhr ihn und er starb She wrote me a letter I answered Then I met her yesterday in the street, and she told me of the death of her uncle. The uncle went for a walk the other day He walked carelessly (literally without great care) across the main road A motor-car ran him down, and he died.

Here is the correct version in the perfect tense:

Sie hat mir einen Brief geschrieben. Ich habe geantwortet. Dann habe ich sie gestern auf der Strasse getroffen, und sie hat mir von dem Tode ihres Onkels erzahlt. Der Onkel ist neulich spazieren gegangen. Ohne grosse Vorsicht ist er über die Hauptstrasse gegangen. Ein Auto hat ihn überfahren, und er ist gestorben

Our Course in German is continued in Volume 5.

LESSON 23

Rome's Rebirth at Constantinople

(See plate 55)

CONSTANTINE THE GREAT is commonly regarded as the second founder of the Roman Empire. Diocletian has the better right to the title, because, except in one important particular, what Constantine did was the logical development of Diocletian's reconstruction, which had reduced Italy to the status of a taxed province and shifted the centre of power to the East. Constantine did, indeed, change the method of succession, which Diocletian had instituted to meet an emergency, but it was Diocletian who chose the passage from Asia to Europe, instead of Italy, as the necessary headquarters of the world-empire—though Constantine found at Byzantium (Constantinople) a better site than Nicomedia in Asia Minor. It was, too, the permanent bureaucratic system of administration which Diocletian created, working automatically, that enabled the empire of the Caesars—though now Byzantine rather than Roman—in spite of disruption, to survive with unbroken continuity through many grave crises for eleven and a half centuries after Diocletian's abdication.

The succession as dictated or ratified by Diocletian before his abdication was accepted but very soon broke down. The half-barbarian Galerius had no personal ascendancy. He and Constantius automatically became Augusti, but the latter died next year, and his son Constantine notified Galerius that he had been obliged to accept his army's nomination as his father's successor. Galerius could only ratify his accession as junior Caesar, while he nominated the western Caesar, Flavius Severus, to be western Augustus. But the Roman Senate, by way of reviving its vanished authority, proclaimed Maxentius, the son of Maximian, instead. Maximian came out of his reluctant retirement to support his son's claims. Flavius was captured and put to death. Maximian claimed for himself the title he had resigned Galerius attempted an invasion of Italy, to enforce the supremacy of his own authority, but thought better of it, retired, and nominated an old comrade in arms, Licinius, as

second Augustus. Maxentius and his father quarrelled, and Maximian had to take refuge in Britain, where he effected a somewhat non-committal alliance with Constantine, who was biding his time, but accepted from him the title of Augustus. In 311 both Galerius and Maximian died. Maxentius prepared to attack Constantine, who anticipated his blow, swooped upon Italy and slew him at the battle of the Milvian Bridge (312). It is affirmed on the authority of Constantine himself that while on the march he had seen displayed in the heavens the vision of the banner of the Cross with the words " Hoc Signo Vinces " (by this banner thou shalt conquer).

He was now sole Augustus in the west, and from the imperial headquarters at Milan he issued the famous decree which made Christianity an officially authorized religion (313). Licinius, who had made no move, published it in the east also. The inevitable conflict between him and Constantine was postponed for nine years, when Licinius made the permission or suppression of Christianity the issue. In 323 Licinius was decisively beaten and died by his own hand. Constantine was the sole and undisputed master of the Roman world.

Reign of Constantine. Constantine reigned alone for nearly fourteen years, dying in 337. In the system of Diocletian he substituted for the two Augusti and two Caesars, four civil prefects holding no military powers, and four pairs of military chiefs, masters of foot and of horse respectively, all being the emperor's officers directly responsible to him and to no one else ; while he designated his sons (of whom at the time of his death the eldest was twenty) as his successors with the courtesy title of Caesar. Certain other necessary modifications he made, but no material constitutional changes. His armies dealt successfully with the barbarians on the frontiers, though at the end of his reign he was planning a campaign against Persia, which was resuming an aggressive attitude after a prolonged interval of truce. He gave to the imperial court, now permanently established in the east, that oriental non-Roman atmosphere and character which it retained thenceforth. But the two outstanding features of his rule were the development of the old trading town of Byzantium into the imperial city and fortress of Constantinople (" Constantine's city "), and the virtual, though not yet the formal, establishment of Christianity, so long proscribed, as the official religion of the empire.

For six years he was building up the City of Constantine into the most magnificent—and impregnable—capital the world had known its formal dedication in 330 is one of the great historical sign-posts In 324 he confirmed the Milan decree with a final edict of toleration, and in the same year presided in person over the great universal council of the Christian Church (which in spite or in consequence of persecution had long been a highly organized body) held at Nicaea, where was affirmed what came to be the orthodox doctrine of the Holy Trinity as against the heresy of Arianism, though its decisive victory was still long deferred Constantine was not a professed Christian—he and his successors for fifty years to come held the office of Pontifex Maximus, official head of the old pagan religion even after baptism But from that time the Church was a powerful organization within the state and always in close association with the imperial government

Julian the Apostate. When Constantine died in 337, on the point of starting to attack the ambitious young Persian king Sapor II, he was succeeded by his eldest son Constantius, who for twelve years was fully occupied with the Persian war, chiefly in Mesopotamia Meanwhile his two younger brothers quarrelled for supremacy in the west Constans won, but when the other, *Constantine II was dead,* he was slain by his own general, Magnentius, who claimed the empire This brought Constantius into the field He patched up a truce with Sapor, overthrew Magnentius, and in 356, being recalled to the east by Sapor's renewed activity sent his young cousin Julian as Caesar to Gaul Julian fought brilliantly against the invading Germans—Franks and Allemanni, but he was already in arms against Constantius when the death of the latter in the east raised him to the imperial throne

Julian "the Apostate" (361–363) is famous chiefly for his attempt to revive a mystical paganism grafted upon Stoicism, he desired to restore the ancient Greek philosophy in place of the conventional Christianity which had been taught him He died in the course of a whirlwind campaign against Sapor, when he had reigned only two years After a brief interval the legions once more elected a great soldier, Valentinian, who took his brother Valens as co-emperor and sent him to the east, since frontier conditions made division an absolute necessity He reigned for twelve years, battling victoriously against the

Germans on the frontier, and on his death was succeeded in the west by his young son Gratian, his child-brother Valentinian II being also named Caesar

Invasions of the Huns. While Valentinian I was holding the Germans in the west, Valens in the east failed to prevent Sapor from absorbing Armenia, and was heading for disaster on the Danube frontier There the hosts of the Goths—western (Visigoths) and eastern (Ostrogoths)—long settled in Dacia, were hard pressed by a new and terrible foe, the Huns migrating from central Asia They appealed to Valens, who, without making provision, transplanted them to Moesia within the empire In the circumstances their condition was so intolerable that in desperation they united in revolt Valens sent for aid to Gratian, who was ill able to afford it and before he could arrive Valens attacked the Goths, but was shattered and slain at the battle of Adrianople (378) The Balkan peninsula seemed to be at the mercy of the victorious barbarians Gratian could do nothing but retreat, but he nominated as successor to Valens Theodosius the Great Having done so, he was himself overthrown and murdered by Maximus, an ambitious general from Britain

Theodosius. All that as yet Theodosius could do was to claim Italy for the boy Valentinian II, while recognizing Maximus in Gaul But when Maximus a little later attacked Valentinian, Theodosius had so strengthened his own position that he was able to come to the rescue and destroy Maximus His patient diplomacy, aided by the revival of the dissensions customary among the Goths, enabled him to enlist them as allies instead of fighting them Then Valentinian was assassinated by his own general Arbogast, a Frank who put up a puppet emperor Theodosius, when he had crushed the rebels, took no colleague , but, in effect, he ensured the permanent partition of the empire into east and west by nominating his elder son Arcadius as his own successor in the east and appointing the younger, Honorius, at once to the throne of the west under the guardianship of the deservedly trusted Vandal general, Stilicho Theodosius, who had received baptism on his accession, attached himself to the orthodox Church , he pronounced that paganism and Christianity could not both be recognized Pagan rites were sternly prohibited and Christianity was officially accepted as the State religion. In 395, the year after the fall of Arbogast, Theodosius died—the last sole emperor of the united Roman Empire.

LESSON 24

Rome at the Mercy of the Barbarians

THEODOSIUS, the last of the great emperors to unite and rule the whole Roman Empire, died in A.D. 395. He left his elder son Arcadius emperor in the East, with a German minister, Rufinus, to direct his counsels, and made the younger son Honorius emperor in the West under the guardianship of the Vandal soldier, Stilicho. The empire was never to be united again, and two generations later both the Western empire and emperors had disappeared. The barbarians on every frontier had been held up, and the Goths had been not only conciliated but imbued with a sort of superstitious awe of the empire, while they had also been induced to profess Christianity—not orthodox but Arian. Nevertheless, Britain, where the legions withdrawn by Maximus in his bid for empire had not been replaced—harassed, too, by the pirate rovers of the Saxon shore—was in a state of grave unrest; on the lower and upper Rhine Vandals, Sueves and Burgundians, Herulians and Rugians were pressing west and south behind the Franks and Allemanni, and Theodosius was hardly dead when Alaric, king of the West Goths, dissatisfied with his position, renewed the attack on the Balkan peninsula, where Rufinus, unable to face the situation, was defeated and slain.

Wars of the Goths and Vandals. The menace in the East was stayed by Stilicho, the captain-general of the West. Having tranquillized the north and quelled disturbances in Africa, he carried his army over to Greece and out-generalled Alaric, who came to terms. Illyria was, in effect, handed over to him by Arcadius, nominally as Imperial governor. Stilicho, having saved the Eastern empire, returned to Italy. But Alaric had only changed his objective; to attack the Western empire was in his eyes no breach of faith with the Eastern. The Goth was a great warrior, but again he found the Vandal Stilicho more than a match for him. Two great battles at Pollentia and Verona drove Alaric and his Goths back (403). Then a host of leagued German tribes burst through the Alps under a common war-lord, Radagaisus, who was duly slain and his forces dispersed by Stilicho.

Meantime Britain, refusing to acknowledge the sovereignty of Rome, set up an emperor of her own, Constantine III, who withdrew most of the remaining troops thence to extend his empire over Gaul in 407, the year commonly assigned to the "evacuation of Britain" Honorius, alarmed by the power, prestige and possible ambitions of Stilicho, seized the moment to deprive himself and the empire of that great defender, in 408 Stilicho was suddenly charged with treason and executed

Sack of Rome. Nemesis came swiftly In two months' time, while Honorius took refuge in the almost impregnable fortress of Ravenna now the imperial capital of the West, Alaric had swept down with his Goths to the gates of Rome itself For the moment he was content to extort a heavy ransom Two years later (410) he returned and put the Eternal City to sack a thing which no foreign foe had done since the Gallic invasion in 382 B.C

All Italy lay at the mercy of the conqueror, but he did not set up a Gothic empire in place of the Roman It would seem that he purposed extending his dominion over the province of Africa without deposing Honorius But before the year was out he died The mysterious reverence with which the barbarians in general and the Goths in particular regarded the empire was demonstrated when his successor, Athaulf, decided to evacuate Italy and march his Goths to Gaul and Spain as something between an ally and an officer of Honorius, this he did in 412 But the fact was manifest that the Western empire had dwindled to Italy, and that even there the emperor of the West no longer ruled except in name

After Stilicho had killed Radagaisus, the composite barbarian forces, no longer held together by a leader, had withdrawn from Italy and poured into Gaul breaking up into component parts The Burgundians stopped on the upper Rhine and Rhône, the Vandals and Sueves swept through southern Gaul into Spain When Constantine III set up his Gallic empire from Britain he did so avowedly to save Gaul from the Germans Athaulf openly marched into Gaul to restore the empire with his own army of Goths He was still preparing to evacuate Italy when Constantine was overthrown and slain by the Roman prefect Constantius, while the Vandals and Sueves were establishing themselves in Spain Thither the Goths, after taking possession of Aquitaine, followed them as hostile imperialists Another infant, Valentinian, succeeded Honorius (who died in 423), the

son of his sister Placidia, who was regent till Valentinian came of age, and married in 437 From that time till 452 the leading man in the Western empire was the soldier Aetius, who was given the title of Patrician

The Vandals in Africa. Now, Arcadius, the emperor in the East died in 408 and was succeeded by his infant son Theodosius II For many years however, the East was left in peace while it took no part in the turmoils of the West In 428 Gaiseric, the king of the Vandals, who had been pushed into Vandalusia, now Andalusia, in Spain, by the Goths, transported himself with the whole Vandal host to Africa, made himself master of the entire province, and established a pirate principality extending as far as Carthage He was restrained in 441 from attacking Sicily—where no effective resistance could have been offered—by the intervention of Theodosius, who, however, practically recognized Gaiseric as sovereign of Africa and of the Mediterranean waters Aetius in the Western empire had been paralysed for effective action against him by other embroilments

The Scourge of God. At this moment the Mongols or Huns developed a portentous attack on the empire "Mongolian" is a general term covering many non Aryan peoples—Huns, Avars, Turks, Magyars, Chinese The "Mongol" proper is the essential Mongolian In their home-land in Central Asia the Mongols were tribes of nomad horsemen Hun was the name given to the typical Mongols who were flooding into Europe in the latter half of the 4th century, hitherto, however, the empire had regarded them rather as a useful curb on the European barbarians, who were a buffer between it and them But about 440 their khan or king, Attila, having established his personal authority over the whole horde, developed ambitions of world-conquest For the next twelve years, adopting the significant name of the "Scourge of God," he was the terror of the whole western world, civilized or uncivilized First, he led his forces over the Danube, swept the Balkan peninsula with fire and sword, and exacted from Theodosius a huge annual tribute (which the emperor preferred to call a subsidy) in 443 However, mainly by way of a demonstration, he repeated the devastating invasion four years later

Then he turned his attention to the Western empire, demanding from Valentinian his sister Honoria for a bride, with half the empire for a dower The demand being scornfully and angrily refused, he carried fire and sword into Gaul; but in the West

Theodoric the Goth and Aetius the Patrician succeeded in combining forces and inflicting on him a tremendous defeat at Châlons (451), which drove him back over the border. Châlons was, in fact, decisive; if the Hun had been victorious the ensuing destruction would have been terrific. Still Attila was not crushed. Next year he was in Italy making unabated demands on Valentinian. Aetius, without the Goths, could not again stake all on a pitched battle. Attila marched on Rome and—retired, overawed, as men believed, by the courage of Pope Leo I, who faced him boldly and threatened him with the wrath of God if he dared advance. A year later Attila was assassinated. Then the German subjects of the Huns rose against them and smote them in a great battle, after which their kingdom fell to pieces, and we hear of them no more.

In 454 Aetius met the fate of Stilicho. Valentinian stabbed him with his own hand, and was consequently himself assassinated some months later. Then, for twenty years emperor succeeded emperor in the West, each one raised to the throne by, or by the consent of, the Sueve Ricimer, who succeeded to the command of the army but contented himself with the title of Patrician. Incidentally, the Vandals came over the sea, professedly at the call of Valentinian's widow, took her prisoner, subjected Rome to a second and very thorough sack, and sailed away again. Ricimer died in 472. Between 472 and 475 Olybrius, Ricimer's last puppet, was succeeded by Glycerius, Glycerius was deposed by Julius Nepos, and Julius by Orestes, the latest "master of the soldiers," who proclaimed his own small son, Romulus Augustus—known consequently as Romulus Augustulus—emperor.

End of the Western Empire. Odoacer, the captain of the miscellaneous German barbarian troops now in Italy, put a check on the chaos by assuming personal authority in an emergency where no legal authority existed, deposing the child Romulus (without harming him), refusing to acknowledge any separate Augustus of the Western empire, whether himself or another, and causing the still existing but powerless Roman Senate officially to declare the loyalty of the West to the Augustus of the East, Zeno, at Constantinople, and to invite him to appoint Odoacer Patrician and viceroy of the West. Thus two generations after Theodosius, in 476, the last of the Western emperors disappeared. Before, however, going on to the medieval period, we must devote two Lessons to ancient history in the Far East.

LESSON 25

Buddhism's Place in Ancient India

(See plate 56)

THE "World as known to the Ancients" included only the northern half of the eastern hemisphere and our chronicle hitherto has been confined to the western half of that portion. Central Asia was inhabited by uncivilized nomad tribes, but beyond it lay China with its civilization as old as Chaldea.

The Indian records of early times are as legendary as those of Homer, and are contained not in historical chronicles but in epic poems. But through the extravagant uncertainty of dates and events certain facts do emerge. The primitive population was mainly Dravidian and dark. Somewhere between 2000 and 1000 B.C. a fair people—calling themselves "Arya," whence the general application of the name Aryan to the peoples who, speaking kindred languages, were presumably of kindred stock—began to penetrate the hill barrier on the north west. By 1000 B.C., probably, they dominated the northern half of India—Hindustan—preserving, though not so completely as they claimed later, purity of race, at least among the upper ranks.

Rise of Caste System. To pride of race the purists added a religious sanction. The Arya were a people apart, the exclusive possessors of religious privileges; their rights would be forfeited if their blood were contaminated. The clans among which the functions of priesthood in their common religion had become hereditary had been the most rigid in preserving racial purity, and separated themselves from the rest. So did the great military clans. Intermarriage between them was forbidden. Occupations tended to become hereditary and exclusive; collateral influences fostered the separatist tendency, and thus grew up the caste system. It was, however, the growth of centuries, and did not attain anything like its full rigidity till a much later date. It is believed to indicate the spiritual status which a man has reached by his continual journeyings through birth and death.

Gautama Buddha. It was probably about the sixth century B.C. that one of the greatest of religious and moral teachers arose in India and founded the religion known as Buddhism

Gautama, Siddhartha, Sakyamuni, or the Buddha, as he is variously called, was a prince in one of the many warring kingdoms into which Hindustan was divided. The Hindus never conquered the south as they did the north, though Hinduism penetrated it and their Brahmans, the highest caste, were no less reverenced or influential there. Abandoning the world, Gautama Buddha gave himself up to the pursuit of holiness and to indoctrinating others with his philosophy. This we cannot discuss here; but it breathes a spirit of charity and toleration and advocates physical non-resistance to evil or aggression. In its purest form it forbids witchcraft, superstition and sacrifice. The idea of purity is expressed in representations of the Devas, angelic beings common to both Hindu Brahmanism and Buddhism. The lotus flower is the sacred symbol.

Empire of Magadha, The veil behind which Indian history is hidden was raised for a moment when Alexander the Great made his famous expedition to the Punjab and forced its princes into his allegiance (as Darius the Great did before him, since there was an Indian contingent in the host with which Xerxes invaded Greece). Conquest, however, was carried no farther. When Seleucus contemplated it, he found that the mighty empire of Magadha had arisen in the Ganges basin under that Chandragupta (not to be confused with the two monarchs of the Gupta dynasty) whom the Greeks called Sandracottus, the founder of the Maurya dynasty with him a friendly treaty seemed preferable to war. Greek envoys visited the court of the mighty monarch and recorded their impressions of the social and political conditions, which, incidentally, show that caste had not yet become a rigid system or Buddhism a dominant creed. Chandragupta had usurped the throne, then, in the character of liberator, attacked and crushed or expelled the Macedonian garrisons left by Alexander in the Punjab, and ended by subjugating the "liberated" kingdoms. With the aid of a Brahman minister as able and unscrupulous as himself, he organized and expanded the Magadha kingdom into an empire embracing all India north of the Nerbudda. His diplomatic fencing with Seleucus won him Afghanistan; and was an effective demonstration of the Magadha military power. The empire was extended again by his son, Bindusara, who conquered half the Deccan and was succeeded in 273 B.C. by his son Asoka, the great advocate of Buddhism.

Reign of Asoka. It is only of late years that the wonderful story of Asoka's reign has been tolerably elucidated, the reign of the greatest idealist who has ever occupied an imperial throne —not excepting Marcus Aurelius—during which a vast subject population enjoyed an unexampled practical prosperity. Asoka began his career on the normal lines of oriental despotism, as a conqueror like his father and grandfather. But his first successes sickened him of war; and it was the victories of peace, not force of arms—though the consciousness of his irresistible strength was, doubtless, a convincing factor—that brought the whole of India except the extreme south under his sway before his death. He early became a fervent disciple of the teachings of Buddha, and the practical application of those doctrines to the principles of government was the basis of his rule. The decrees which were the expression of his aims were recorded from time to time on rock inscriptions, and were finally summed up in his seven pillar inscriptions, and are at the same time an exposition of the moral law of Buddhism. Moreover, Asoka dispatched missionary expeditions far and wide beyond the borders of his own dominion, so that the great religion took possession of Ceylon and Burma and continued to plant itself farther afield, till it had more professed followers probably than any other creed, though it never became securely rooted in India itself. He made no more conquests; but, besides preserving friendly relations with the contemporary Seleucids, he held amicable communication with the Ptolemies.

Of his successors we know almost nothing. During the second century B.C. the great Maurya empire broke up—it may be, in consequence of a Brahmanist reaction against Buddhism, which could not be brought into line with the strict caste ideas of Hinduism. Though it professed not to disturb social order, Buddhism seemed to the Brahmans a danger to the Hindu state, because it withdrew from military service into a life of philosophic contemplation too many of the fighting caste, and received even people of invading forces of Greeks, Scythians, Parthians, and Huns into its fold, a proceeding which the pure-blooded Brahmans could not tolerate.

Kushan Empire. About the beginning of the Christian era one of the Central Asiatic hordes established in Afghanistan the Kushan dominion, which presently expanded over Hindustan; probably it was not Mongol so much as Turkish. Kanishka,

the greatest of its monarchs, would seem to have set about a Buddhist revival complicated by a curious admixture of other religions The Kushan empire in turn disappeared, and on its ashes arose, early in the fourth century A D —when Constantine was building his New Rome on the Bosporus—the Gupta empire, founded by another Chandragupta (c A D 320), followed by his son Samudragupta, and then by the second Chandragupta of the Gupta dynasty The three reigns covered about a century, an era of restoration and conquest—the classic age of Hindu literature, art and science

Great Gupta Dynasty. Samudragupta (c. A D 326-375), after a brilliant campaign, forced the Indian rulers of the extreme south to pay him tribute A riderless steed, in accordance with the ancient Vedic ritual was let loose to show his armies the way to victory, afterwards it became the victim of the sacrifice which concluded the campaign Though a strict Hindu, Samudragupta never persecuted other religious sects Buddhism received its full share of State patronage, and its founder was revered as one of the greatest of early religious teachers. The monasteries of Buddhism became real universities and schools of comparative religion, its noble ethics making what has proved a permanent impression on Hindu thought

After Samudragupta, the Gupta power lasted another fifty years. At this period western civilization was tottering from the shock of Attila and his Huns; but at the same time a Hun empire was being established in the east, which was about to dominate, without exterminating, the Gupta dominion The dynasty remained in being till the 7th century The evidence of the power and prosperity of the Gupta period is drawn rather from the very high development of Indian art and architecture, touched though not inspired by Hellenistic culture, and from the note-books of the Chinese traveller Fa-hien, who went all over India in the days of Chandragupta II, than from the compilations of Brahmans of later centuries, and from these evidences we are warranted in regarding the great Gupta era as a golden age in Indian history And just as Latinism was never wholly submerged by the Teutonic flood, so also Hinduism emerged triumphant from the Hun flood in India.

LESSON 26

Early History of China and Japan

(See plates 57 and 58)

THE historical generalization that States, following the law of organic life are born, have their period of adolescence of fully developed vigour, of inevitable decay, and death, is impossible to reconcile with the story of China, a state still so much alive that it is a member of the League of Nations while it has a continuous history as a continuous state from beginnings in a past so remote that we cannot assign its birth even to a given millennium much less a given century

In the sixth century B C, when Darius the Great was organizing the Persian empire which Cyrus had created, the great Chinese sage Confucius (551-478 B C), was compiling from existing records part of the history of his nation in the Book of Spring and Autumn, while other historical works included in the "Scriptures of Confucianism go back to a period long before the sage's own work Yet China's contacts with the West have been of the most meagre description during the four thousand years of her chronicled existence, until the last century

The Chinese people, like most of the Far Eastern Asiatics, are Mongolians, akin to but not identical with the Mongols proper or Huns of central Asia In the very earliest times they developed a relatively high civilization of their own in a highly organized state, and the enemies against whom they had to be perpetually on guard were those same Mongols or Huns According to the Confucian books the reasonably trustworthy, as opposed to the merely legendary, records depicted an organized empire stretching from Peking to Canton at the time when the historical survey contained in these Chinese Classics starts It opens with the founders of the Hsia dynasty, which lasted some five hundred years, and was followed by the Shan or Yin dynasty, which endured for 500 years more Their great monarchs, Yao, Shun, Yu, and Tang, were probably, like Minos, Midas or the great Pharaohs of the early Egyptian dynasties, real persons who became centres of legend In the twelfth century arose the Chou dynasty, founded by Chang or Wen Wang and his son Wu Wang, known as the "wise king" and the "warrior king"

China Under the Chous. The dynasty may have been of foreign extraction, like William the Conqueror's At any rate, the Chou empire was organized on lines akin to the feudal system of medieval Europe—Egypt, it may be remembered, had something like a feudal period of its own, when great territorial magnates were virtually petty princes owing allegiance to a common sovereign, who might, or might not, be able to exercise effective authority over them. The mightiest of these barons were the lords of the border provinces, the men charged with the defence of the marches against the barbarian raids and attacks on a larger scale; these chieftains may be compared to the barons of the Welsh and Scottish marches under the Normans and Plantagenets. It is curious also to note that in the 10th century B.C. an innovating emperor, Mu Wang, was introducing a reform in the criminal law very shocking to Chinese conservatism, this was the substitution of fines on a regulated scale for the vindictive penalties assigned by immemorial custom to offences against the law.

Lao-Tsze. The imperial Chou dynasty had been on the throne for some 600 years when Confucius was born The empire at that time had long been an aggregate of virtually independent principalities. Philosophy and learning were held in very high account in China. An older contemporary of Confucius was the great philosopher Lao Tzŭ (or Lao-tsze, literally "the old philosopher"), whose *Tao Te Ching* is one of the great ethical treatises of the world. The fundamental qualities extolled in it are humility, gentleness and economy. *Tao* means the path or way, and Lao Tzŭ's "great way" provided the name for the Chinese religion of Taoism. There is, however, nothing concerning this type of religious worship in Lao Tzŭ's treatise, and the phases which Taoism has assumed at different times have no connexion with the high ethical teachings of the philosopher

Confucius. Unlike Lao Tzŭ, who valued academic matters not at all, Confucius was a man who devoted himself primarily to learning and was most zealous to turn it to practical account as a moral teacher and a political reformer. In this last respect he was highly efficient, when allowed a free hand, not as a prince but as a minister of princes, thus carrying on the ancient Chinese tradition of ruler and advisory sage. He enunciated "Do not do to others what you would not have them do to you" as the golden rule of conduct and of perfect manners. He laid great stress on the duty of everyone to cultivate his best qualities and

suppress the bad. Knowledge was his key to virtue. There is at the heart of things a fixed order or rhythm. Thus the study of music and poetry assist the cultivation of virtue.

Confucius, died when about seventy, in humble belief that his life had been a failure; but after his death his countrymen revered him almost as a divinity, and today Confucianism still represents the morality and intelligence of China. In spite of his originality as a reformer, Confucius was fundamentally conservative in his reverence for tradition and the past glories of his nation. He attributed the evils of his own day to the degeneration of morals since the great days of Wen Wang, and Wu Wang. Neither he nor his famous disciple, the philosopher Meng Tse (Mencius)—who devoted his life to Confucian propaganda, and who found the root of state trouble in the lack of a central authority and the disregard of rulers for the welfare of their subjects—succeeded in bringing about any real reconstruction. Thus the Chou dynasty degenerated, and finally succumbed in the 3rd century to the lords of T'sin.

The Burning of the Books. For a time there was no official emperor, but in 221 B.C. Shi Hwang Ti seized the imperial crown. It was he who built the Great Wall of China—1,500 miles of fortification, of which Hadrian's Wall in Britain would have been an insignificant fraction—as a barrier against Hun incursions; in one gigantic act of censorship he ordered the "Burning of the Books," the total obliteration of the whole literature of China, because the learned classes were wont to invoke the Classics in their resistance to any sort of reform, which had convinced him that the super-education of the privileged classes was a deadly political disease. Though the punishment for refusing to surrender any books was death—which some hundreds at least of recalcitrants suffered—the destruction was fortunately not complete, and the next generation did its best to make good some portion of the otherwise irreparable loss, partly from memory, partly from the materials which had been successfully secreted.

Golden Age of the Hans. Shi Hwang Ti was the first despotic emperor of all China. He did not found a dynasty, but a few years after his death the Han dynasty was established by Kao Tsu, and confirmed by Wen Ti (178 B.C.). Both reversed the anti-clerical policy of Shi Hwang Ti, but otherwise made him their model. The two centuries of the Han rulers were China's

golden age of strong and peaceful government, when the land enjoyed prosperity; art and literature flourished exceedingly, and there was some expansion of the northern borders and the conquest of Korea. Its glory ended with the usurpation of the traitor Wang Wung of execrated memory, at the beginning of the 1st century A.D. He was very soon overthrown, and the line of the Hans was restored as the eastern Han dynasty, which, however, presents no notable features except the definite admission of Buddhism into China under its first emperor. Trade, especially in silk, was carried on through Parthia, and Roman merchants reached China by sea in A.D. 166.

The empire broke up into three kingdoms, not to be reunited as a single whole till the 6th century, though the northern kingdom expanded its dominion over a considerable portion of central Asia, for it was in the north that China was at all times engaged in interminable wars with the Mongol barbarians.

Early Japan. The earliest external references to Japan occur in the days of the eastern Han. The point of contact was, as might be expected, Korea. In the first century A.D. the "Little People" of the islands, the Wa, were in communication with the Koreans. The Chinese annalists describe them picturesquely; but these stray references do little more than confirm the Japanese tradition of an organized kingdom or empire, which had already been in existence for an indefinite number of centuries.

It is not till the end of the 5th century A.D. that some degree of exactitude begins to attach to Japanese history. Little reliance can be placed on the records of the Japanese themselves, since their compilation cannot be attributed to a date before the 8th century A.D. Those records, however, claim that the Japanese empire dates from the first Mikado Jimmu, 660 B.C., whose lineal descendant is Mikado today.

The most prominent figure in the Japanese tradition is that of the Empress Jingo, who is said to have conquered Korea in the third or fourth century A.D. All we can say with certainty is that there was much intercourse between Korea and Japan, and that writing seems to have been introduced from the former by means of Chinese books and teachers of Confucianism. The true introduction of Chinese civilization, however, came in A.D. 552, when Buddhism was introduced from Korea into Japan, and eventually became the state religion.

Our Course in Ancient and Medieval History is continued in Volume 5.

LESSON 15

Some Peculiarities of Verbs

THE frequentative verbs in Latin grammar express repeated or intenser action, and are formed either (1) in *-tō*, *-sō*, from supine stems—e.g. *tractō* = I handle (from *trahō, traxī, tractum* = I draw); *cursō* = I run about (from *currō, cucurrī, cursum* = I run); or (2) by adding *-itō* to the last consonant of the present stem—e.g. *rogitō* = I ask often. All frequentatives are first conjugation.

The inceptive verbs express beginning of action, and are formed by adding *-scō* to the present stem of verbs, or from nouns by adding *-āscō* or *-ēscō*—e.g. *juvenēscō* = I begin to grow young; *ignēscō* = I burst into flame. All these are third conjugation.

The desiderative verbs express desire, and are formed by adding *-uriō* to the supine stem—e.g *ēsuriō* = I am hungry (from *edō, ēsum* = I eat) All these are fourth conjugation.

The quasi-passive verbs are the exact opposite of deponents. Deponents are passive in form and active in meaning; quasi-passives are active in form and passive in meaning—e.g. *fīō* = I am made; *exulō* = I am banished; *liceō* = I am put to auction; *vapulō* = I am beaten; *veneō* (compound of *eō* = I go) = I am on sale (used as the passive of *vendō* = I sell).

The defective verbs lack some of a verb's usual parts:

1. *Odī* (I hate), *meminī* (I remember), *coepī* (I begin), are perfects, without any present-stem tenses. *Nōvī* (I know), from *nōscō*, is similarly used. Thus: "To hate" = *ōdisse*; "I remembered" = *memineram* (pluperfect).

Meminī has imperative *mementō, mementōte*.

Coepī and *ōdī* have perfect and future participles—*coeptus* and *coeptūrus, ōsus* and *ōsūrus*.

2. Many verbs have perfect without supine, and some have neither perfect nor supine—e.g. most of the inceptive verbs.

3. *Inquam* (I say) has the following parts:

	1	2	3
Present.	*inquam*	*inquis*	*inquit*
	inquimus	*inquitis*	*inquiunt*

	1	2	3
Imperfect.	—	—	*inquiēbat*
	—	—	*inquiēbant*
Future	—	*inquiēs*	*inquiet*
Perfect	—	*inquistī*	*inquit*
Imperative	—	*inque*	—
	—	*inquīte*	—

Aiō (I say ay, I affirm) has:

	1	2	3
Present	*āiō*	*ais*	*ait*
	—	—	*āiunt*
Imperfect	*āiebam* (complete)		
Pres subj	—	*āiās*	*āiat*
	—	—	*āiant*

Fārī (to speak)—deponent—has *fātur* (he speaks) *fābor* (I shall speak), *fāre* (speak thou), *fārī fātus, fandus*

The impersonal verbs are conjugated only in the third person singular of the finite verb, and in the infinitive

1 The following are used with the accusative *oportet* (it behoves) *decet* (it beseems), *dēdecet* (it misbeseems), *piget* (it irks), *pudet* (it shames), *poenitet* (it repents), *taedet* (it wearies), *miseret* (it moves pity)—all second conjugation, also, *dēlectat* (it charms), and *juvat* (it delights)—first conjugation

2 The following are used with the dative *libet* (it pleases), *licet* (it is lawful) *liquet* (it is clear)—second conjugation, also *accidit, contingit* (third) *evenit, convenit, expedit* (fourth)

Examples *oportet me īre* = I must go, *licuit tibi rīdere* = you were allowed to laugh

3 *Pudet, piget, taedet, poenitet, miseret,* are used with an acc of the person feeling and a genitive of what causes the feeling *taedet me vitae* = I am weary of life

4 *Interest* and *refert* (it concerns, or it is important for) take the genitive of the person concerned—e g *Caesaris interest pontem facere* = it is Caesar's interest to build a bridge (This construction is rare with *refert* say, *ad Caesarem refert*) But *possessive pronouns* are used in the *ablative feminine*—e g *Quid meā refert* = What does it signify to me? *Magis nullīus interest quam tuā* = It concerns no one more than yourself

The *meā* and the *tuā* probably agree with *rē* understood *Meā rēfert* was originally *meae rei fert*, and then, *rei* being shortened

to *rē*, *meae* became *meā*. If this is so, *meā interest* is probably an imitation.

The following irregular verbs of the first conjugation are important exceptions :

	Perfect *-uī*.	Supine *-ītum*.		
crepō	*crepāre*	*crepuī*	*crepitum*	creak

Similarly, *cubō* (lie down), *domō* (tame), *plicō* (fold), *sonō* (sound), *tonō* (thunder), *vetō* (forbid).

	Perfect *-uī*.	Supine *-tum*.		
secō	*secāre*	*secuī*	*sectum*	cut
	Perfect reduplicated.	Supine *-tum*.		
dō	*dare*	*dedī*	*datum*	give
stō	*stāre*	*stetī*	*statum*	stand
	Perfect *-vī*.	Supine *-tum*.		
juvō	*juvāre*	*jūvī*	*jūtum*	help
lavō	*lavāre*	*lāvī*	*lōtum* or *lavātum*	wash

NOTE. Compounds of *dō* are of third conjugation, and make *-didī*, *-ditum* (except *circumdō*, *pessumdō*, and *venumdō*, which make *-dedī*, *-datum*). Compounds of *stō* form *-stitī*, *-stitum*.

Put the following into English, using a dictionary before consulting the translation :

PERORATION OF CICERO'S SECOND PHILIPPIC.

Respice, quaeso, aliquando rempublicam, M. Antoni : quibus ortus sis, non quibuscum vivas considera : mecum, ut voles : redi cum republica in gratiam. Sed de te tu videris : ego de me ipso profitebor. Defendi rempublicam adolescens, non deseram senex : contempsi Catilinae gladios, non pertimescam tuos. Quin etiam corpus libenter obtulerim, si repraesentari morte mea libertas civitatis potest : ut aliquando dolor populi Romani pariat, quod jam diu parturit. Etenim si abhinc annos prope viginti hoc ipso in templo negavi posse mortem immaturam esse consulari, quanto verius nunc negabo seni ? Mihi vero, patres conscripti, jam etiam optanda mors est, perfuncto rebus iis quas adeptus sum quasque gessi. Duo modo haec opto ; unum ut moriens populum Romanum liberum relinquam—hoc mihi majus ab dis immortalibus dari nihil potest—alterum, ut ita cuique eveniat ut de republica quisque mereatur.

NOTE. " Perfuncto " is dat. of the perf. ptc., agreeing with " mihi " ; it governs an abl., being a compound of " fungor."

TRANSLATION.

Bethink yourself of the State, I beseech you, even now, Marcus Antonius: think of those from whom you have sprung, not of those with whom you now associate: deal with me as you like, but make up your quarrel with the State. About your own course, however, you yourself will decide: I will openly profess my own. I defended the State in my youth, I will not abandon it in my age: I scorned the swords of Catiline, I will not fear yours. Nay, rather I would gladly offer my body, if by my death the freedom of the State can be immediately recovered, so that at last the pangs of the Roman people may give birth to that with which they have so long been in travail. If, nearly twenty years ago I said in this very temple that death could not be untimely for one who had filled the consulship, how much more truly shall I say this now of an old man! For me indeed, Senators, death is even to be desired, now that I have completed the course of honour and of achievement.

I have only two wishes. One is that at my death I may leave the Roman people free—and no greater gift than this could be granted me by Heaven! The other is that as each man has deserved of the State, such may be that man's reward.

LESSON 16

Oblique Narration

THE construction known as Oblique Narration (*Oratio Obliqua*), or the Accusative and Infinitive Construction, is one of the most characteristic idioms of Latin. It is especially used where English has a clause beginning with *that* after (1) verbs of saying, knowing, thinking, believing, feeling, (2) impersonal expressions, as "it is clear, true," etc.

The subject is put in the accusative case, and all principal verbs are changed from indicative to infinitive, retaining their original tenses: e.g. he says that the moon is smaller than the sun = *dicit lunam esse minorem sole* (literally, he says the moon to be smaller). I know that I shall die = *scio me moriturum esse.* Instead of *dico . . . non,* Latin uses *nego* = I deny: e.g. he said he did not believe = *negavit se credere.*

All verbs, other than principal verbs (i.e. verbs directly making

a statement), are put in the subjunctive There cannot be an indicative in Oblique Narration This is very important

Examples · "the slaves whom I now have here are most faithful" is in *Oratio Recta* (Direct Narration) and would be in Latin, "*servi quos nunc hic habeo sunt fidelissimi*" Turn this into "reported speech" or *Oratio Obliqua*, and we have "he said that the slaves whom he then had there were most faithful" = *dixit servos quos tum ibi haberet esse fidelissimos* Note the change of "now" into "then" "here" into "there," "I" into "he," "have" into "had," and "are" into "were" but we still use *esse* for "were," because *esse* is both present and imperfect infinitive, and *fuisse* would mean "had been" Again "It is clear that, because the citizens are cowards, the city will be taken" = *manifestum est quod cives ignavi sint urbem captum iri*

Imperatives in *Oratio Recta* become imperfect subjunctive in *Oratio Obliqua* e g *Recta* "Charge, my men," said the general = "*Instate, milites*" *inquit imperator* *Obliqua* The general said to his soldiers, "Let them charge" = *Imperator militibus dixit Instarent*

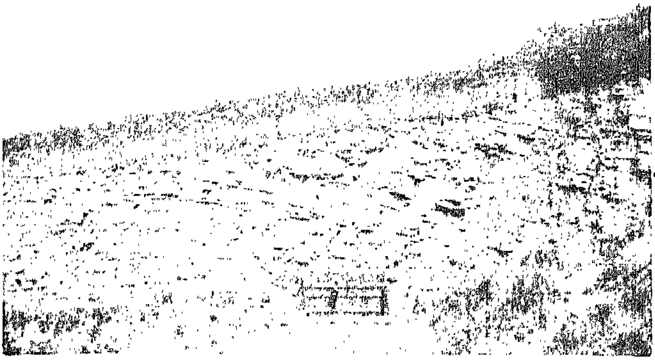
Questions in the first and third persons are rendered in *Oratio Obliqua* by the accusative of the person and the infinitive of the verb, but questions in the second person become imperfect or pluperfect subjunctive e g (they said) why is our general absent? = *cur abesse imperatorem?* (he said) why are you advancing? = *cur progrederentur?*

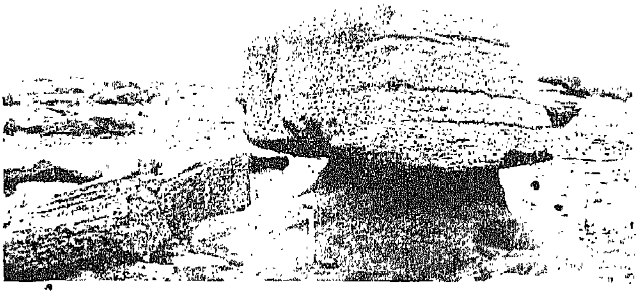
Ego, tu, nos, vos, cannot find a place in *Oratio Obliqua*, *ego* and *nos* become *se*, *tu* becomes *ille*, and *vos* becomes *illi*

Se and *suus* refer, as a rule, to the speaker e g he says that he will come = *dicit se venturum esse* He said, "let them not forget his kindnesses" = *ne suorum beneficiorum obliviscerentur*

If, however, *suus* is wanted to refer to the subject of some subordinate verb (e g *obliviscerentur*, above), then *ipse* is used to refer to the speaker e g. let them not forget their own cowardice or his kindnesses = *ne suae ignaviae aut ipsius beneficiorum obliviscerentur*

NOTE The translation of the English conjunction *that* needs great care When it means "in order that," "so that" (as "he walked fast that he might warm himself"), it should be translated by *ut* with subjunctive When it means "the fact that," after any verb or phrase *sentiendi vel declarandi* ("of



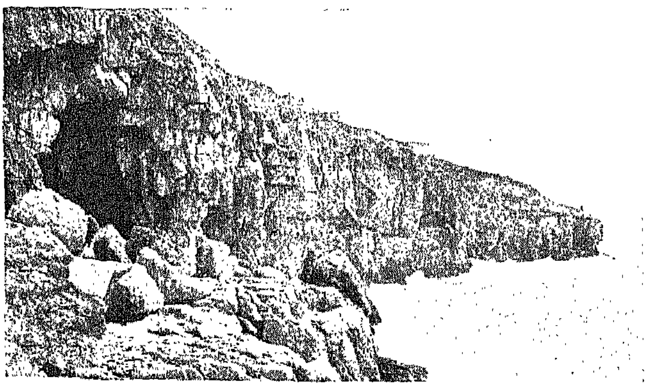


LIASSIC FORMATIONS IN BRITAIN. Upper photo, a quarry in the Lower Lias limestone at Bridgend, Glamorgan; middle, an isolated block of Middle Lias sandstone on a pillar of shale, on the foreshore at Sheepstone, Yorks; bottom, Upper Lias cliffs at Saltwick bay, Yorks. GEOLOGY 16

Courtesy of the Geological Survey and Museum

ARCHAEOPTERYX. Possessed of teeth as well as beak, with fingers as well as feathers on its wings, the archaeopteryx (Gr. ancient wing), of which a fossilized specimen is illustrated above, was a link between modern birds and primitive reptiles.
GEOLOGY 17

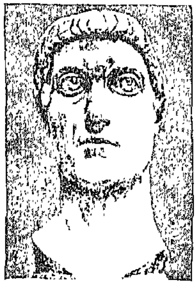
Berlin Museum



PORTLANDIAN OOLITE. Portland stone, named after the Isle of Portland, in Dorset, where it is extensively quarried for building purposes, belongs to the Upper Oolite series. Above is a view of the Portland stone cliffs—Tilly Whim and Durlstone Head—near Swanage, Dorset. GEOLOGY 17

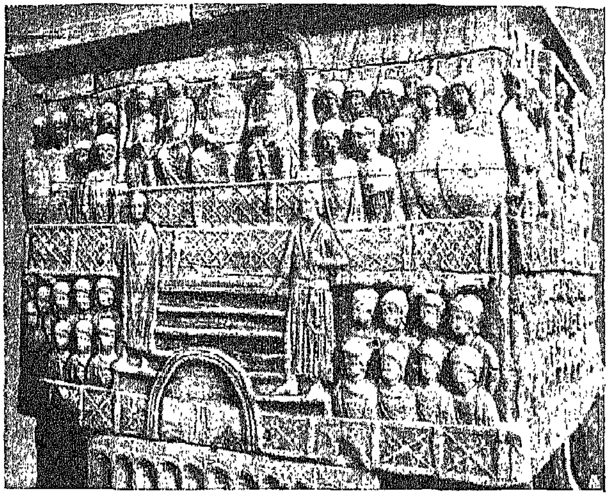
Geological Survey and Museum

DIOCLETIAN (A.D. 245–313). Emperor from 284 until his abdication in 305, he was mainly responsible for the reconstruction of the empire as an absolute monarchy with its centre of power in the east. HISTORY: ANCIENT 23



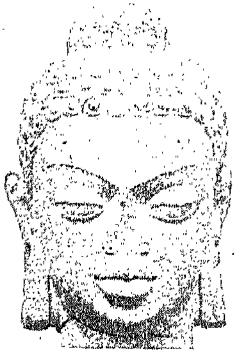
CONSTANTINE THE GREAT. (A.D. 288–337). Proclaimed emperor in 306, he transferred the imperial capital to Constantinople, ordering the toleration of Christianity.

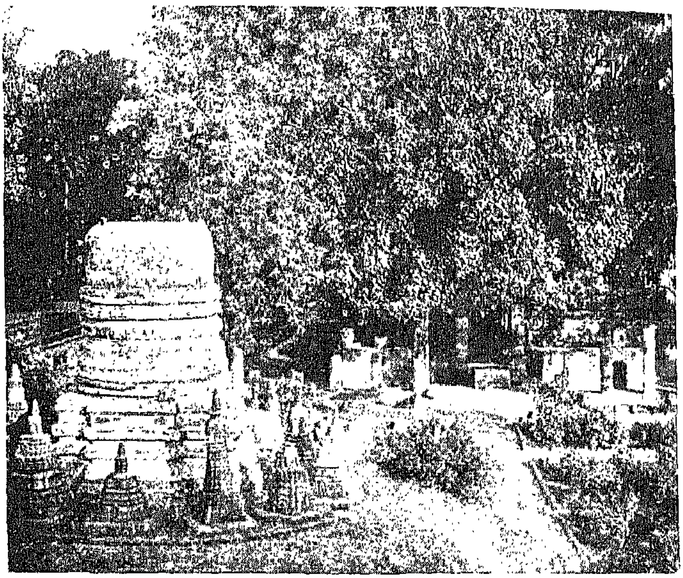
HISTORY: ANCIENT 23



THEODOSIUS AT THE GAMES. This bas-relief on the pedestal of an obelisk in Constantinople, erected by Theodosius in A.D. 390, shows the emperor and his suite watching the games in the Hippodrome.
HISTORY: ANCIENT 23

Photo, A. J. B. Wace in Journal of Hellenic Studies





BUDDHA. Born about 560 B.C., Gautama was almost thirty when he left wife and child and went in search of the key to life and death. After seven years of wanderings and self-mortification he came to the forest of Gaya, in Bihar, and there while meditating beneath a bo-tree illumination came. Thenceforth he was the Buddha, the wise or enlightened one. The reputed spot is shown in this photograph; on the left is the famous shrine, the Buddh-gaya, while on the right, encircled by a brick platform, is the fig-tree which is perhaps a descendant of the tree that shaded Buddha. Above is a sculptured head of the great teacher, the work of a Gupta artist. Buddha died about 480 B.C. HISTORY : ANCIENT 25

Photo, F. Deaville Walker

feeling or stating "), the accusative with the infinitive must be used. In English we can say, "you were ill, he thought, and therefore absent." But in Latin we must say, "he thought that you were ill, etc." (*putavit te aegrotare*).

Latin prose composition can be learned only by long and constant practice. Below will be found a passage for translation into Latin. This done, the student should compare his rendering with the Latin version, and then translate the latter literally into English, after which he should compare his English version with the English version as given above. This will give him a good idea of the difference between the English and the Latin ways of expressing ideas. Accuracy and clearness are the first essentials, and then the style should be polished by constant comparison with the style of the best Latin authors, such as Livy and Cicero. Hints on style will be given from time to time during the remainder of this Course.

TURN INTO LATIN PROSE:

The inhabitants of this island were so bold that they would have preferred a thousand deaths (say, "to die six hundred times") to disgrace, if the choice had been necessary. One brave farmer was asked why he would sooner die nobly on the field of battle than live ignobly at home. He answered, "Because I am more afraid of shame than of death." It happened once that they were invaded by the powerful nation of the Ventidii, who landed on their shores, marched up to their capital, devastated the country all round, and then laid siege to the city. The citizens determined to resist with boldness. Instead of throwing themselves at their enemies' feet, they sent away their families, their old men and their treasures, and prepared to resist with desperation. Though they were prevented by scruples from committing suicide, they promised one another to fight so desperately that the enemy should not take them alive. When they were all assembled in arms, their general addressed them thus: "Remember, citizens, that victory or death awaits you. I will say no more; the enemy is at the gates. What reason is there for delaying?"

LATIN VERSION.

Qui in hac insula habitabant ii omnes quum essent summa audacia praediti, sescentiens mortem quam semel, si optandum fuisset (gerundive = "if it had to be chosen, if choice had to be made") infamiam obire maluissent. E quibus agricola

quidam, vir fortissimus, rogatus cur potius vellet militiae per virtutem emori quam per dedecus domi vivere, respondit se ignominiam magis quam mortem timere. Quibus ita accidit ut Ventidii, quae gens erat potentissima, in eorum fines navibus ingressi, agris undique vastatis, urbem quam maximam habebant obsiderent. Sed quum civibus visum esset sibi quam acerrime hostibus obstandum (gerundive), tantum aberat ut se iis ad pedes deiicerent ut, pecuniis et liberis et senibus dimissis, sese ad resistendum accingerent ut (as) qui de suis rebus desperarent. Religione quidem obstricti quominus sibi mortem consciscerent, alii tamen aliis pollicebantur sese acrius pugnaturos quam qui ab hostibus vivi caperentur. Quos quum armatos imperator convocasset (shortened form of *convocavisset*), jussit meminisse aut victoriam aut mortem obeundam : se non plura dicturum ; hostes illis ad portas adesse : quid causae (partitive genitive, literally " what of reason ") esse cur jam morarentur ?

LESSON 17

Writing the Date

IN the Roman calendar, the year originally began with March ; therefore, July was the fifth, September the seventh month, and so on. Every Roman month had three chief days ; *Kalendae, -ārum* (Calends) ; *Nōnae, -ārum* (Nones) ; *Idūs, Iduum* (Ides) : all three feminine The Calends were always on the 1st . the Nones usually on the 5th, and the Ides usually on the 13th. But in March, May, July and October, the Nones and Ides were two days later, i.e. on the 7th and 15th respectively.

From these days the Romans counted *backwards*, the days between the 1st and the Nones being reckoned as so many days before the Nones ; the days between Nones and Ides, as many days before the Ides ; and the remaining days of the month as so many days before the Calends of the next month.

In expressing dates, the Romans generally employed the names of the months as adjectives :

Jānuārius, a, um	*Māius, -a, -um*
Februārius, -a, -um	*Jūnius, -a, -um*
Martius, -a, -um	*Quintīlis, -e* (or *Jūlius*)
Aprīlis, -e	*Sextīlis, -e* (or *Augustus*)

September, -bris, -bre *November -bris, -bre*
October, -bris, -bre *December -bris, -bre*

Quintilis and *Sextīlis* were later called *Jūlius* and *Augustus* in honour of Julius Caesar and the Emperor Augustus

When the date falls on one of the three chief days, the date is put in the abl, the month, of course, agreeing with the noun.

Jan 1, *Kalendīs Jānuāriīs*

March 15, *Idibus Martiīs*

Nov 5, *Nōnīs Novembribus*

The day immediately preceding any of these three reckoning points was called *prīdiē* (i e *priōre diē*), followed by the acc.

Jan 31 *Prīdiē Kalendas Februārias*

Apl 12 *Prīdiē Idūs Aprīlēs*

Oct 6. *Prīdiē Nōnas Octobrēs*

In any other date we find out how many days it is before the next Calends, Nones or Ides (remembering to count in both the date in question *and* the Calends, etc) Thus Jan 30 is the *third* day before the Calends of February, and would be in Latin *ante diem tertium Kalendas Februārias*

Further examples

Dec 2 *Ante diem quartum Nōnas Decembrēs.* March 16. *a d septimum decimum Kalendas Aprīlēs.*

These are usually written "a d IV Non Dec.," and "a.d. XVII Kal Ap" and so with the others. The original signification of this expression seems to have been "before (on the fourth day) the Nones of December," the exact day being thrown in parenthetically, and attracted from abl to acc. in consequence of following *ante*.

In Leap Year, Feb 24 (a d VI Kal. Mart.) was reckoned twice, hence this day was called *diēs bissextus*, and leap year itself, *annus bissextīlis*

Irregular Verbs. In the second conjugation, the most important exceptions to the regular formation of *-uī* and *-itum* are:

Perfect *-vī*, Supine *-tum*

dēleō	*dēlēre*	*dēlēvī*	*dēlētum*	blot out

(So also *fleō* = weep, and *-pleō* = fill.)

Perfect *-uī*, Supine *-tum*

doceō	*docēre*	*docuī*	*doctum*	teach
misceō	*miscēre*	*miscuī*	*mīstum*	mix
teneō	*tenēre*	*tenuī*	*tentum*	hold

Perfect *-si, -xi*, Supine *-tum*.

torqueō	*torquēre*	*torsī*	*tortum*	twist
augeō	*augēre*	*auxī*	*auctum*	increase
lūgeō	*lugēre*	*lūxī*	—	mourn

Perfect *-si*, Supine *-sum*.

mulceō	*mulcēre*	*mulsī*	*mulsum*	soothe

Similarly, *ārdeō* (take fire), *rīdeō* (laugh), *suādeō* (advise), *maneō* (remain), *jubeō* (order, perf *jūssī*), *haereō* (stick), *fulgeō* (glitter).

Perfect *reduplicates*, Supine *-sum*.

mordeō	*-ēre*	*momordī*	*mōrsum*	bite
pendeō	*-ēre*	*pependī*	*pēnsum*	hang
spondeō	*-ēre*	*spopondī*	*spōnsum*	pledge
tondeō	*-ēre*	*totondī*	*tōnsum*	shear

Perfect *-ī*, Supine *-sum*

prandeō	*-ēre*	*prandī*	*prānsum*	dine
sedeō	*-ēre*	*sēdī*	*sēssum*	sit
videō	*-ēre*	*vīdī*	*vīsum*	see

Perfect *-ī*, Supine *-tum*

caveō	*-ēre*	*cāvī*	*cautum*	beware
faveō	*-ēre*	*fāvī*	*fautum*	favour
foveō	*-ēre*	*fōvī*	*fōtum*	cherish
moveō	*-ēre*	*mōvī*	*mōtum*	move
voveō	*-ēre*	*vōvī*	*vōtum*	vow

NOTE. Most of our English nouns are derived from supines e.g. torture, tonsure, vision, session, etc.

Also three deponents:

fateor	*fatērī*	*fassus*	confess
misereor	*miserērī*	*misertus* or *miseritus*	have pity on
reor	*rērī*	*ratus*	think

Turn the following, "The Funeral of Oliver Cromwell," by Abraham Cowley, into Latin prose.

It was the funeral-day of th late man who made himself to be called Protector And though I bore but little affection, either to the memory of him, or to the trouble and folly of all public pageantry, yet I was forced by the importunity of my company to go along with them, and be a spectator of that solemnity, the expectation of which had been so great that it was said to have brought some very curious persons (and no doubt singular virtuosos) as far as from the mount in Cornwall

and from the Orcades I found there had been much more cost bestowed, than either the dead man or indeed death itself could deserve There was a mighty train of black assistants among which, too divers princes in the persons of their ambassadors (being infinitely afflicted for the loss of their brother) were pleased to attend, the hearse was magnificent the idol crowned, and (not to mention all other ceremonies which are practised at royal interments, and therefore by no means could be omitted here) the vast multitude of spectators made up, as it uses to do, no small part of the spectacle itself

LATIN VERSION OF THE ABOVE

Dies erat quo inferebantur tumulo reliquiae illius qui Protectoris nomen occupaverat Me, quamvis neque viri memoriae neque operosae publicarum sollemnitatum vanitatis admodum studiosum, perpulere tamen sociorum preces ut cum iis spectarem pompam illam, quae tam cupide jamdudum fuerat expectata, ut nonnulli curiosiores, limatissimo nimirum ingenio homines, usque a monte apud Cornubios et ab Orcadibus insulis visendi causa in urbem progressi essent Intellexi multo plus in funus erogatum esse quam pro mortui meritis immo pro mortis ipsius dignitate Ingens pullatorum ordo assistentibus etiam quibusdam legatis qui regum personas fratrem summo studio desiderantium sustinerent feretrum splendidissimum, coronata effigies, denique, ne omnia alia commemorem quae, utpote in regum funeribus sollemnia hic nullo modo omitti poterant, pars haud exigua spectaculi fuit, ut fit vasta spectantium multitudo.

LESSON 18

Use of the Subjunctive Mood

ONE of the most difficult subjects in Latin is the subjunctive mood English usage gives no guidance and, in fact, the subj is as common in Latin as it is rare in English In the following sentences, for example, the words in italics would be in the subj mood in Latin " It was so cold that the water *froze* " (consecutive after *ut*) " I asked why he *did* this ? " (indirect question) ' I fear that you *are* ill ' He said that the man who *did* this should die " (dependent verb in Oratio

Obliqua). "There is no doubt that twice two *are* four." Roughly, we may say that the indicative indicates a fact, while the subj. expresses "something which we regard rather as a mere conception of the mind, as that which we purpose or wish to be a fact, or to which we refer as the result of another fact, or as stated on other authority than our own"

As a general rule the subjunctive is used in certain classes of subordinate or *subjoined* clauses But it is also used both in simple sentences and in the main clause of a compound sentence in the following cases :

1. To make a statement in a hesitating manner, sometimes called the potential mood. This is strictly a hypothetical subj. with the condition not formally expressed. *Hoc dicere ausim* = I would dare to say this (if I were allowed)

2. To ask a question, rhetorically, not for information, sometimes called dubitative questions Usually a negative answer is expected. *Quis credat?* = who would believe?

3. To express a wish or desire (optative or jussive), often with *utinam* (= would that!). Negative *ne*. *Utinam adjuvisset* = would he had been present! *Di Carthaginem deleant* = may the gods destroy Carthage

Only in these classes of sentences is the subj found in simple or principal sentences In all the rest it is in subordinate sentences Including those given above, there are eight main uses of the subj. mood :

1. Hypothetical : see No. 1 above. In these sentences the protasis (i.e the *if* clause of a conditional sentence) is suppressed.

2. Conditional—e.g. *Si jussisses* (protasis), *fecissem* (apodosis) = if you had bidden, I should have done it.

3. Optative, jussive, or concessive (see No 3 above). "The imperative is the language of an absolute master; the subj. is a suggestion to an equal or superior"

In concessive sentences, a person rhetorically commands or supposes a change of what he knows or believes to be the fact.

4. Final, expressing purpose (negative *ne*).

(*a*) In adjectival sentences : *Dignus est qui vincat* = he is worthy to conquer (*b*) In sentences introduced by *ut* (in order that), *ne*, *quo*, *quominus*, *quin* *Ede ut vivas* = eat that you may live (*c*) In sentences of time or condition, with *dum*, *dummodo*, *donec*, *priusquam*, etc. : *Oderint dum metuant* = let them hate provided they fear.

5 Consecutive, expressing result, usually with *ut* = so that (negative, *ut non*) *Tam debilis sum ut non ambulare possim* = I am so feeble that I cannot walk *Is sum qui illud faciam* = I am the man to do that

6 Subj of attendant circumstances *Quae quum ita sint, hoc dico* = under these circumstances (lit since which things are so), I say this *Peccavisse videor qui illud fecerim* = I seem to have sinned inasmuch as I have done that

7 Subj of reported statements, comprising sentences of definitions, reasons, and questions, which are given *not as the speaker's own*, but as someone else's

Contrast "Laudat puerum quod *fuit* abstinens" (the reason alleged being given on the speaker's own authority) with "Laudat puerum quod *fuerit* abstinens (the reason being a reported or assumed one, He praises the boy, because he understands the boy to be abstemious ')

8 Subj because dependent on another subj or infinitive In all such sentences the subjunctive simply prevents the speaker from being supposed to be responsible for the statements, etc, reported, or to be giving them as independent assertions To this head, of course, belongs the subj in Oratio Obliqua

(*a*) Depending on infinitive

Dicit eos qui boni sint beatos esse (he says that those who are good are happy)

(*b*) Depending on another subjunctive

Petit ut iis adfuerint credamus (he asks that we should believe those who were present) In such a case as this it is often said that *adfuerint* is *attracted* into the subj by *credamus*

TRANSLATION

The following passage, a letter from Cicero to his friend Atticus, written in March, 46 B C, should be translated into English without consulting the English version given below

"Undecimo die postquam a te discesseram, hoc litterularum exaravi egrediens e villa ante lucem, atque eo die cogitabam in Anagnino, postero autem in Tusculano, ibi unum diem V Kalend igitur ad constitutum, atque utinam continuo ad complexum meae Tulliae, ad osculum Atticae possim currere! quod quidem ipsum scribe, quaeso, ad me, ut, dum consisto in Tusculano, sciam quid garriat, sin rusticatur, quid scribat aq te, eique interea aut scribes salutem aut nuntiabis, itemque Piliae

Et tamen, etsi continuo congressuri sumus, scribes ad me, si quid habebis

"Cum complicarem hanc epistolam, noctuabundus ad me venit cum epistola tua tabellarius, qua lecta de Atticae febricula scilicet valde dolui Reliqua quae exspectabam, ex tuis litteris cognovi omnia; sed quod scribis 'igniculum matutinum gerontikon' (a Greek adjective, meaning characteristic of an old man'), gerontikoteron (comparative) est memoriola vacillare ego enim IV Kal Axio dederam, tibi III, Quinto, quo die venissem, id est prid Kal Hoc igitur habebis, novi nihil Quid ergo opus erat epistola? Quid? cum coram sumus et garrimus quicquid in buccam? Est profecto quiddam 'lesche' (gossip), quae habet, etiam si nihil subest, collocutione ipsa suavitatem"

ENGLISH VERSION

"Eleven days after leaving you, I am scrawling this bit of a note as I am starting from my country-house before dawn I think of being at my villa at Anagnia today, and Tusculum tomorrow Only one day there, so I shall turn up to time on the 28th, and, oh that I could run on at once to embrace my Tullia and give Attica a kiss! As to this very thing, do write me, I beg you, that while I am stopping at Tusculum I may know what she is prattling or, if she is in the country, what she writes to you about Meanwhile, either send or give her my love, and also to Pilia Yet even though we shall meet immediately, write to me if you have anything to say

"P.S When I was fastening up this letter, your courier reached me after travelling all night with your letter. I am very sorry, you may be sure, to hear, on reading it, about Attica's fever. All the other news I was waiting for I now know from your letter, but when you write that 'to want a little fire in the morning is a sign of old age,' I retort 'it is a surer sign of old age that one's poor memory should falter' For I had intended to spend the 29th with Axius the 30th with you, and the 31st with Quintus. So take that for yourself you shall get no news Then why write, you say? And pray, what is the use of our chattering when we are together and saying whatever comes to our tongues? Surely there is something in a good gossip after all; for even if there is nothing in it, the very act of our talking together has a charm of its own"

Our Course in Latin is continued in Volume 5.

MATHEMATICS

LESSON 29

Plane and Solid Geometry

MEASUREMENTS on flat surfaces or planes are made along lines which are either straight or arcs of circles These lengths are recorded in codes as linear units such as yards or metres versts or miles or in terms of circular units, as radians i e in terms of π in circles of different radii Areally, on the flat measurements are in square units, such as a square inch or square centimetre It is necessary to realize that when 3 feet = 1 yard, 3^2 square feet = 1 square yard and since 100 centimetres = 1 metre 100^2 square centimetres (i e 10 000 sq cm) = 1 square metre

Since 60° 90° and 120° are all integral fractions of 360° the plane regular figures of which these are the angles, i e the equilateral triangle the square and the hexagon can be repeated to cover a section of a plane surface, i e can be used to measure areas Current practice has for convenience retained the square as the unit areal shape but there is no theoretical necessity that we should not use the equilateral triangle as the unit shape for areal measurement The area of an equilateral triangle of unit side is $\frac{1}{4}\sqrt{3}$ so that 1 triangular areal unit would equal $\frac{1}{4}\sqrt{3}$ square units

Cubically or solidly, measures are in cubic units as cubic feet, it would be possible to devise a cumbersome set of solid measures in terms of octahedra and tetrahedra jointly in sets of 1 octahedron and 4 tetrahedra such measures would lack the simplicity which attaches to the use of cubes as the solids of unit capacity The relation now is 12 inches = 1 foot 12^2 inches^2 = 1^2 foot^2, 12^3 inches^3 = 1^3 foot^3 i e 1728 cubic inches = 1 cubic foot

Oddly shaped rectilinear figures are the most frequent They do not readily split into square shapes they easily split into triangles which are most frequently scalene triangles Hence it is important to determine the relation between a scalene triangle and a square in other words to fix the area of a scalene triangle in square measure

Two straight lines meet a third straight line AB at A and at B (Fig 1). If these lines AD and BC are parallel, then the three

lines do not enclose an area—they do not form a figure. If AD and BC are not parallel, they will meet somewhere and form a triangle of which AB is the base, i e a triangle is determined by a vertex (a meeting of two sides) in position in reference to a given base. The argument may proceed thus

(i) a triangle ABC and its reversed image CBD on the axis of symmetry BC (Fig 2) together form a parallelogram, for reversed images are the essence of parallel lines The shape and size of the original triangle ABC are preserved position only being changed, and its area is half that of the parallelogram ACDB

(ii) the parallelogram gives rise to the triangle BED (Fig 3), where BE is the common perpendicular to the two parallel lines AB and CD, the triangle DEB may be moved to the position CFA, hence the rectangle AFEB is equal in area to the parallelogram ACDB hence the shape of the original triangle has been lost, but its area is retained as half the area of the rectangle AFEB i e the area of a triangle is half the area of a rectangle on the base of the triangle with the vertex of the triangle on the side of the rectangle opposite to the base, in Fig 3 the shape has gone, since the area of the triangle is now determined by the size of the base AB in relation to any point C in the line FD, we have lost precision of shape to gain precision of areal measurement

FIG 1

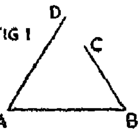
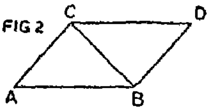


FIG 2



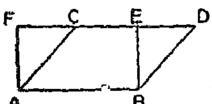


FIG 3

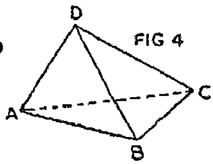


FIG 4

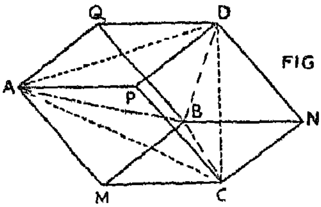


FIG 5

(iii) a rectangle can be split into a number of equal squares, each of which may be regarded as a unit of area hence the area of a triangle can be expressed in square measure

Since areal measurement of triangles ignores shapes, an infinite number of triangles may have the same area A triangle is not completely " known " when its area is " known " The distance

between the base and the opposite side of the rectangle determines what is called the vertical height of the triangle ; hence triangles on the same base and with the same vertical height are equal in area, but usually different in shape. Hence the areas of triangles with the same vertical height vary in terms of the bases of the triangles. Hence triangles with the same, or equal, vertical heights are equal in area when the bases are equal. Since parallelograms comprise pairs of triangles, set to a pattern, parallelograms on the same base or on equal bases and with the same perpendicular distance between a corresponding pair of sides are equal in area.

We now pass to the solid From the three corners of a triangular base three lines project. When these lines are parallel they will not meet ; when two are parallel the three will not meet in a common point. When the three converge to a common point, then the six lines are the edges of a solid (Fig. 4). ABCD is such a solid, an irregular triangular pyramid or tetrahedron. Such an irregular figure has six unequal edges, four unequal solid angles.

A figure made when two pairs of parallel lines intersect is a parallelogram. A solid made when three pairs of parallel parallelograms intersect is a parallelepiped ; it is a "brick "on the skew." In Fig. 5, BNCM and QDPA are a pair of parallel parallelograms. BNDQ and MCPA are a second pair of parallel parallelograms, and MBQA and CNDP are the third pair of parallel parallelograms. B is a solid angle where three faces of the solid come together , BA, BD, and BC are the respective diagonals of these three faces. DA, DC, and AC are diagonals of the other three faces of the solid. ABCD are the corners of an irregular tetrahedron. Hence the parallelepiped may be cut into five irregular tetrahedra, ABCD, ABCM, CBDN, DBAQ, and ACDP.

In Fig. 3 the parallelogram ABDC is a skewed rectangle ABEF, and the two are equal in area. But Fig. 3 may be the front elevation of a parallelepiped, which is a skewed brick or prism, hence the parallelepiped and the prism are equal in volume, for the excess to the right of BE could be moved to fit CA on the left to comprise the prism.

Hence, whatever fraction of the area of the parallelepiped (Fig. 5) equals the volume of the tetrahedron ABCD, the tetrahedron is that fraction of the volume of the prism equivalent

to the parallelepiped, i.e. to the unskewed parallelepiped. Unskewing alters shape, but not volume, just as in the flat it alters shape but not area. The student may find it necessary to think out the unskewing in two stages—first, from right to left, and, secondly, from front to back; there is no unskewing upward and downward, since the vertical height throughout is predetermined as a constant. More of this in the next Lesson.

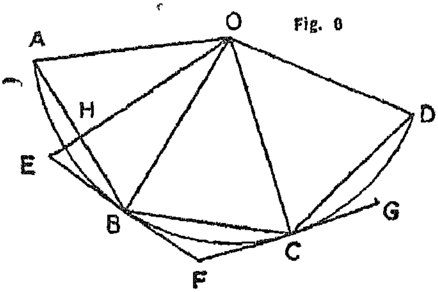


Fig. 6

Drill. 1. A motor cyclist is lapping a circular track. His times for successive laps are 18 and 17 seconds. He maintains his acceleration steadily. What is his time for his third lap? If his initial average speed for the first lap is 30 m.p.h., what is his speed in m.p.h. for the third lap?

2. At what rate of compound interest per annum would £735 amount to £873 in 4 years?

Revision. Revise the argument of Lesson 22, Vol. 3, p. 492, by which the relation between the volume of a regular tetrahedron and its containing cube was established.

Expansion. A spot of light is known to be moving round a circular track. An observer sees the light moving backwards and forwards between A and B, the extremities of a straight line AB. He can determine the apparent rates of movement of the spot of light. Determine the relation between the apparent and actual rates of motion of the spot of light. Plot a diagram in illustration.

Solutions to Problems in Lesson 28.

Drill. 1. (i) $30x + 29$; (ii) $4x^3 - 6x^2 - 26x - 14$.

2. (i) $2/(m + 1)^2$; (ii) $-CA/(B - Am)^2$.

Revision. 1. M does 1/105 per hour; N does 1/112; together they do 31/1680. Ans.: $5\frac{13}{31}$ days.

2. Let the unit be the wages for a boy's hour's work. The man earns A/B when the boy earns 1. If A/B is less than 1, the ideal team has no boys. If A/B equals 1, the ideal team has any number of men with any number of boys. If A/B is greater than

1, the ideal team has no men If the team must contain both boys and men the ideal team has B men and A boys

Expansion In Fig 6 O is the centre of the circle AB = BC = CD = a side of the inscribed "gon" EF = FG = a side of the circumscribed "gon" $OA = OB = OC = OD = 1$ Let angle BOH = a Then area of AOB = HO HB The area of FOF = EB BO The geometric mean of these areas = $\sqrt{HO\ HB\ EB\ BO} = \sqrt{\sin a \cos a \tan a} = \sin a$ Hence the G M for an n gon = $n \sin \frac{\pi}{n}$, for a hexagon $= 6 \sin 30 = 3$, for an octagon $= 8 \sin 22\frac{1}{2} = 3\ 05$

At the limit of experience when n is very large, the angle is very small and the angle and its sine are equal, and the G M, then $= \pi$ Also the inscribed and circumscribed "gons" are, then, almost indistinguishable from the circle all of area π But π was put into the argument as the ratio of the diameter of a circle to its circumference, and π emerges from the argument as the ratio of the area of a circle to the square on its radius

LESSON 30

Measurement of Volume

THE measurement of the areas depends upon (i) the square, (ii) the fact that a rectangle can be split into an integral number of squares provided the unit of length be such that the length and breadth of the rectangle can be measured as integers, (iii) the fact that any triangle may be suitably "enclosed" within a rectangle, so that the area of the triangle is half the area of the enclosing rectangle, (iv) the fact that any irregular rectilineal figure i e, an n-gon, can be split into a fixed number of triangles, one for each rectilineal side of the figure, hence square measure is a suitable measure for areas of rectilineal figures By combining the conception of π as a definite determination of the essential relation between a circle and its enclosing square, it is possible to use square measure on the π scale to measure the areas of circles The areas of other curved figures are found upon suitable scales when the area of the shape has been related to the square-shape and a constant such as π has been determined The whole process lies in the

determination of scalar relations between standard shapes, so that $2k$ is the area of a shape which is such that unit shape has area k square units, e.g., 2 is the area of a circle and the size of the circle areally is twice the size of a circle which has an area of 1 square unit

This argument may be extended to the measurement of volumes. The rectilineal unit is the cube. The "brick" solid, the normal box shape with length and breadth and height in three dimensions at right angles, can be split into an integral number of unit cubes. this implies that each of the six faces of the brick has an area which can be measured integrally in the corresponding square units A skewed brick is a parallelepiped

If ABCD and MNPQ are two parallel faces of a parallelepiped and X be any point in ABCD, then XMNPQ is a pyramid with base MNPQ of constant area in square units and with a vertical height determined by the fact it is the fixed height of the solid. Let the area of MNPQ be D square units, and let H be the fixed height, then the volume of the parallelepiped is HD cubic units and the volume of the pyramid XMNPQ is kHD cubic units where k is a constant for the relation between the solid shapes of pyramid and enclosing parallelepiped. k is, therefore a shape-ratio universally true, and is the extension into volumes of the similar ratio $\frac{1}{2}$, which is the shape-ratio between triangle and enclosing parallelogram.

In the pyramid XMNPQ the base is a parallelogram MNPQ, so that the pyramid XMNPQ is twice the volume of the pyramid XMNP, which is the simplest pyramid-shape, i.e., an irregular tetrahedron.

Any rectilinear solid with n-faces each a triangle can be split into n-tetrahedra, hence the volumes of rectilinear solids can be measured in cubes as soon as the essential relation between the cube-shape and the tetrahedron-shape is known.

In Lesson 22 (Volume 3, page 492) it was shown that a cube of unit edge could be split into a regular tetrahedron of edge $\sqrt{2}$, with four faces each of area $\frac{1}{2}\sqrt{3}$ square units, and four pieces which fitted to make half an octahedron of edge $\sqrt{2}$, i.e., four times an octahedron of edge $\frac{1}{2}\sqrt{2}$; and that, since a tetrahedron of edge $\sqrt{2}$ is twice the volume of an octahedron of edge $\frac{1}{2}\sqrt{2}$, the tetrahedron of edge $\sqrt{2}$ is a third the volume of a unit cube. Whence it was determined that the volume of a regular tetrahedron was equal to one-third the product of the

base area and the vertical height. But a skewed cube is a parallelepiped, hence a parallelepiped contains an irregular tetrahedron hence the ratio one-third is the shape-ratio universally true for the relation between tetrahedron-shape and cube-shape

Irregular tetrahedra can be measured volumetrically in cubic measure, hence rectilinear solids can be measured volumetrically in cubic measure.

Hence spheres and cylinders can be measured volumetrically in cubic measure on the π-scale, and other solid shapes can be similarly measured in cubic measure provided the suitable shape ratios can be determined.

All this means that the customary use of long measure, square measure, and cubic measure depends initially upon the shapes of a straight line, a square, and a cube, and that the extension of these measures to other shapes depends solely upon the possibility of determining the shape-ratio between the other shape and the straight line and the square and the cube, i.e., upon the determination and tabulation of shape-constants such as $\frac{1}{2}$, $\frac{1}{3}$, π. The student is advised to extend the following summary:

(1) In 2 dimensions the area enclosed by joining a point to the 2 ends of a straight line equals $\frac{1}{2}$ the area of the parallelogram which encloses the triangle so made.

(2) In 3 dimensions the volume enclosed by joining a point to the 3 corners of a triangle equals $\frac{1}{3}$ of the volume of the parallelepiped which encloses the pyramid so made.

(3) The area of a parallelogram equals the area of a rectangle on an equal base with an equal vertical height

(4) The volume of a parallelepiped equals the volume of a prism with an equal basic area and an equal vertical height.

(5) At the limit of experience a circle is a regular n-gon i.e., a regular figure with an infinitely large number of equal edges each infinitely small, hence the volume of a cone equals $\frac{1}{3}$ of the volume of a cylinder with an equal basic area and an equal vertical height. This is also the relation between a skewed cone and its enclosing skewed cylinder But solids have surface area as well as volume.

(6) The surface of a cube $=6$ times the area of each face. If the edge $=M$, the surface $=6M^2$, the volume $=M^3$.

(7) The surface of a regular tetrahedron $=4$ times the area of each face If the edge $=N$, the surface $=\sqrt{3}N^2$, the volume $=\frac{1}{12}\sqrt{2}\,N^3$; and the enclosing cube has an edge $\frac{1}{2}\sqrt{2}\,N$.

(8) $\dfrac{\text{Volume}}{\text{Surface area}}$ = for a cube M/6, for a tetrahedron $\sqrt{6}$ N/36

(9) In a cube : $\dfrac{6 \text{ volumes}}{\text{surface area}}$ = vertical height = M.

(10) In a regular tetrahedron : $\dfrac{4 \text{ volumes}}{\text{surface area}} = \sqrt{6}$ N/9, i.e., vertical height = $\sqrt{6}$N/3.

(11) Ratios : $\dfrac{\text{tetrahedron}}{\text{enclosing cube}}$: (a) $\dfrac{\text{vol.}}{\text{vol.}} = \frac{1}{3}$; (b) $\dfrac{\text{edge}}{\text{edge}} = \sqrt{2}$;

(c) $\dfrac{\text{height}}{\text{height}} = \dfrac{2\sqrt{3}}{3}$.

Triangles have inscribed and circumscribed circles. The centre of the in-circle is the point of concurrency of the bisectors

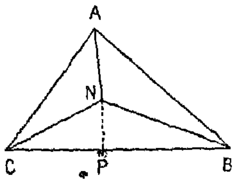


Fig. 1

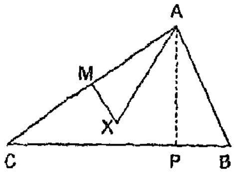


Fig. 2

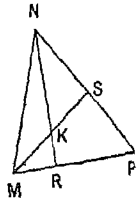


Fig. 3

of the angles (Fig. 1). The radius = NP = r. The area of the triangle ABC = r (semi-perimeter of the triangle), hence

$$r = 1/s\ \sqrt{s(s-a)\ (s-b)\ (s-c)},$$

$$\text{whence } r = \sqrt{\frac{(s-a)\ (s-b)\ (s-c)}{s}}$$

The centre of the circum-circle is the point of concurrency of the perpendiculars at the mid-points of the sides, so that the sides are chords of the circum-circle (Fig. 2).

The radius = XA = R. Angle AXM = angle B.

$$\text{Hence } 2R = \frac{b}{\sin B} = \frac{c}{\sin C} = \frac{a}{\sin A}$$

In Fig. 2 area of ABC = $\frac{1}{2}$AP.a = $\frac{1}{2}$ ac. sin B, i.e., area of ABC = abc/4R.

But area of $ABC = rs$. Hence $R.r. = abc/4s$. Regular tetrahedra have three spheres: inscribed, circumscribed, and "mid-side."

Fig. 3 is the cross-section of a tetrahedron. $NP = 2$ = the edge of the tetrahedron. $MN = MP = \sqrt{3}$ = perpendicular of a triangular face, so that $MR = \frac{1}{3}\sqrt{3}$, $RP = \frac{2}{3}\sqrt{3}$, and $NR = \frac{2}{3}\sqrt{6}$. K is the common centre of all three spheres, so that $NK = \frac{3}{4}$ $KR = \frac{3}{4}$ NR, whence $NK = \frac{1}{2}\sqrt{6}$ and $KR = \frac{1}{6}\sqrt{6}$.

$MS = \sqrt{2}$; $MK = KS = \frac{1}{2}\sqrt{2}$

$KN = \frac{1}{2}\sqrt{6}$ = radius of circum-sphere $= R$

$KS = \frac{1}{2}\sqrt{2}$ = radius of mid-side sphere $= m$

$KR = \frac{1}{6}\sqrt{6}$ = radius of inscribed sphere $= r$; i.e., $R = m\sqrt{3} = 3r$; or $m = \sqrt{R.r}$; i.e., the radius of the mid-side sphere is the geometric mean of the radii of the in- and circumspheres.

The volume of this tetrahedron, of edge 2, $= \frac{2}{3}\sqrt{2}$, and the area of each face $= \sqrt{3}$. But $R = \frac{3}{4}$ of the vertical height, $\frac{3}{4}$ of $2/3 \sqrt{6} = \frac{1}{2}\sqrt{6}$.

Drill. Find the surface area of the tetrahedron ABCD, when it is known that $AB = 4$, $AC = 5$, $AD = 6$, angles $BAC = 70°$, $CAD = 60°$, $DAB = 50°$.

Revision. 1. Solve the equation $x - y = 3$, $x^3 - y^3 = 117$.

2. Use the solution of (1) to solve:

(i) $(x+3)^3 - (y-2)^3 = 40$; $x = y - 3$;

(ii) $(x-n)^3 - (y+p)^3 = a$; $x - y = b$.

3. By substituting z for $-y$ in (1) solve the equation $x^3 + z^3 = 117$; $x + z = 3$.

Expansion. m^3 steps down to $3m^2$, $3m^2$ steps down to $6m$. Use these relations in connexion with the volume, surface area, and vertical height and length of edge $= x$ of a regular tetrahedron to find a tetrahedral constant T of the same character as the circular constant π.

Solutions to Problems in Lesson 29.

Drill. 1. Let D = lap distance in yards, V = first lap speed in yards per second; then $D = 18V$; second lap speed $= 18V/17$; acceleration $= V(1/17^2)$ in yards per second; let T = time in seconds for third lap; then speed for third lap $= V(18/17 + T/17^2)$; whence $T = (18.17^2)/(18.17 + T)$; whence $T = 16.15$ and speed in miles per hour for the third lap $= 33\frac{1}{3}$.

2. By logs 873 735 = 1·043, whence rate = 4·3% approx. Rough check . S I on £535 @ 4·3% for 4 years = £125

Expansion. Draw AB and a circle with AB as diameter as in Fig. 4. From his observations M, N, P, are successive positions apparently in AB. Project to the circle. Let OM = ½AB = ½, then KO = AO − AK. KO = cos AOM. KO can be determined, hence angle AOM can be determined, hence arc AM is determined. Similarly arcs AN and AP can be determined The times for the true motion from A to M and from A to N are observed. The true distances AM and AN are known as a ratio; whence the comparison of the ratio between the observed times and the ratio between the true distances determines the relation between the apparent and the actual speeds.

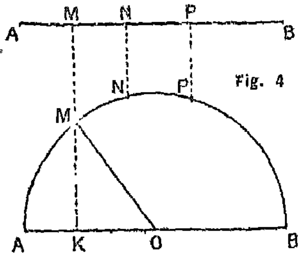


Fig. 4

LESSON 31

Natural Numbers and Their Summations

THE counting scale gives us the natural numbers : 1, 2, 3, 4, etc., which we divide into the odd sequence 1, 3, 5, etc., and the doubled odd sequence, i.e. the even sequence, 2, 4, 6, etc. In the sequence of natural numbers the *n*th term is n ; in the sequence of odd numbers the *n*th term is $(2n-1)$, in the sequence of evens the *n*th term is 2n. Since the jumps from term to successive term in these sequences are regular, the principal of the average is applied to their summation. The average of the first n natural numbers is $\frac{1}{2}(n+1)$. The sum of the first n natural numbers is $\frac{1}{2}n(n+1)$. A new symbol now appears : Σ for sum of ; so that in code

$$1+2+3+4+ \ldots +(n-1)+n=\tfrac{1}{2}n(n+1)=\Sigma n$$

In the sequences of the powers of the natural numbers, e.g. 1, 4, 9, 16, etc., i.e. the squares, the jumps are uneven. It is required to find the sum of the first n squares

$$=(1^2+2^2+3^2+4^2+\ldots\ldots+(n-1)^2+n^2)$$

$$n^3-(n-1)^3=3n^2-3n+1$$

$$3^3-2^3 = 3\ 3^2-3\ 3+1$$
$$2^3-1^3 = 3\ 2^2-3\ 2+1$$
$$1^3-0^3 = 3\ 1^2-3\ 1+1$$

By addition keeping the two sides of these equations apart, and supplying mentally the intervening steps between $n^3-(n-1)^3$ and 3^3-2^3,

$n^3 = 3\Sigma n^2 - 3\Sigma n + n$ whence

$3\Sigma n^2 = n^3 + 3\Sigma n - n$

$\quad = n^3 + 3\left(\frac{1}{2}n(n+1)\right) - n$ whence

$\Sigma n^2 = \frac{1}{2}n\,(n+1)$ times $\frac{1}{3}\,(2n+1)$

The sum of the cubes may be similarly found

$$n^4-(n-1)^4 = 4n^3-6n^2+4n-1$$

$$3^4-2^4 = 4\ 3^3-6\ 3^2+4\ 3-1$$
$$2^4-1^4 = 4\ 2^3-6\ 2^2+4\ 2-1$$
$$1^4-0^4 = 4\ 1^3-6\ 1^2+4\ 1-1$$
$$n^4 = 4\Sigma n^3-6\Sigma n^2+4\Sigma n \quad -n$$

$\Sigma n^3 = \frac{1}{4}n^2(n+1)^2 =$ the square of Σn

The results similarly obtained may be summarized, using a new code symbol $3\,!$ is called factorial 3, and is the code symbol for the continued product of the first 3 natural numbers, so that $3\,! = 6$ and $4\,! = 24$ and $7\,! = 5040$ and $12\,! = 479001600$ The dimensions of factorial 99 may be inferred from the following log $99\,! = 155\ 97000365$

$$\Sigma n = \frac{1}{2}n\,(n+1)$$

$$\Sigma n^2 = \frac{1}{3\,!}n(n+1)\,(2n+1)$$

$$\Sigma n^3 = \frac{6}{4\,!}n^2(n+1)^2 \qquad = (\Sigma n)^2$$

$$\Sigma n^4 = \frac{4}{5\,!}n(n+1)\,(2+1)\,(3n^2+3n-1)$$

$$= \frac{1}{5}(3n^2+3n-1)\ \Sigma n^2$$

$$\Sigma n^5 = \frac{60}{6\,!}n^2(n+1)^2\,(2n^2+2n-1)$$

$$= \frac{1}{3}(2n^2+2n-1)\ \Sigma n^3$$

The student is advised to try the method by working out Σn^4 or Σn^5 for himself and checking his result against the summarized values

Reciprocals. 3 and $\frac{1}{3}$ are reciprocals, their product is unity [illegible] and [illegible] are reciprocal Tan A and cot A are reciprocal We use

a new symbol for the reciprocal, a minus in the index. 3^{+1} and 3^{-1}, x^2 and x^{-2}, $m^2 n^{-3}$ and $m^{-2} n^3$ are reciprocal pairs.

Reciprocity of this character appears in logs thus:

10^x and 10^{-x} are reciprocals.

If $10^x = A$ and $10^{-x} = B$, then A and B are reciprocal, i.e. $\log A = x$ and $\log B = -x$; this means that logs which add to zero are logs of a reciprocal pair.

$\log 3 = 0{\cdot}4771$, $\log \frac{1}{3} = -0{\cdot}4771 = \bar{1}{\cdot}4229$.

Hence the following table:

n	n !	log n !	$\log\frac{1}{n\,!}$	$\frac{1}{n\,!}$
1	1	0·0000	0·0000	1
2	2	0·3010	$\bar{1}$·6990	0·5
3	6	0·7782	$\bar{1}$·2218	0·16666667
4	24	1·3802	$\bar{2}$·6198	0·04166667
5	120	2·0792	$\bar{3}$·9208	0·00833333
6	720	2·8573	$\bar{3}$·1427	0·00138889
7	5 040	3·7024	$\bar{4}$·2976	0·00019841
8	40 320	4·6055	$\bar{5}$·3945	0·00002480
9	362 880	5·5598	$\bar{6}$·4402	0·00000276
10	3 628 800	6·5598	$\bar{7}$·4402	0·00000028

Obviously, the increasing size of the values in column 2 shows that the sum of successive factorials increases not only indefinitely, but with accelerated rapidity.

Equally obviously, the increase on the number of 0.0000 in column 5 shows that the sum of successive reciprocals of factorials tends towards a constant, for the increments per term in the summation diminish with accelerated rapidity; this constant is one of the fundamental constants of the universe, and is universally known by the code symbol e, so that

$$e = 1 + \frac{1}{1\,!} + \frac{1}{2\,!} + \frac{1}{3\,!} + \frac{1}{4\,!} + \frac{1}{5\,!} + \frac{1}{6\,!} \text{ etc.}$$

The sum of column 5 above is 1·71828180, whence an approximation for e = 2·718282 . . .

It will be obvious that if columns 1 and 3 are printed in a book of reference tables the other values can be readily obtained to the degree of accuracy given by column 3.

A second method of determining the value of e comes about thus:

$$(1+x)^n = 1+nx+\frac{n(n-1)}{2!}x^2+\frac{n(n-1)(n-2)}{3!}x^3 \text{ etc.}$$

Let n be the largest number possible at the limit of experience, and let x be the reciprocal of n; then

$$\left(1+\frac{1}{n}\right)^n = 1+\frac{n}{n}+\frac{n(n-1)}{2!\,n^2}+\frac{n(n-1)(n-2)}{3!\,n^3}$$
$$+\frac{n(n-1)(n-2)(n-3)}{4!\,n^4}$$

and so on, and this simplifies to

$$\left(1+\frac{1}{n}\right)^n = 1+1+\frac{1}{2!}\left(1-\frac{1}{n}\right)+\frac{1}{3!}\left(1-\frac{1}{n}\right)\left(-\frac{2}{n}\right)$$
etc.

but at the limit of experience 1 is indistinguishable from

$$\left(1-\frac{1}{n}\right) \text{ or } \left(1-\frac{2}{n}\right) \text{ or } \left(1-\frac{3}{n}\right), \text{ so that}$$

$$\left(1+\frac{1}{n}\right)^n = e \quad \text{(Result A)}$$

When the number of terms is infinite similarly

$$\left(1+\frac{1}{n}\right)^{nx} = 1+x+\frac{x^2}{2!}+\frac{x^3}{3!} \text{ etc.} = e^x \quad \text{(Result B)}$$

whence it follows that $e^0 = 1$ and $e^{-x} = \frac{1}{e^x} = 0$

and, also, that

$$e^{ax} = 1+ax+\frac{a^2x^2}{2!}+\frac{a^3x^3}{3!}+\frac{a^4x^4}{4!} \text{ etc. (Result C)}$$

and

$$e^{bcx} = 1+bcx+\frac{b^2c^2x^2}{2!}+\frac{b^3c^3x^3}{3!} \text{ etc.}$$

whence, when $e^c = a$ so that $c = \log_e a$

$$a^{bx} = 1+bx\log_e a+\frac{(bx\log_e a)^2}{2!}+\frac{(bx\log_e a)^3}{3!} \text{ etc.}$$
(Result D)

The results A, B, C, D should be tabulated and memorized.

Drill. Tabulate the next values for n = 11, 12, 13, 14, 15 from the table above.

Revision. A rectangular tank is 10 ft by 5 ft by 4 ft What is its capacity for water in gallons given that 1 gallon = 0 16057 cubic feet? Make a table showing the reduction in water capacity when the base of the tank is fixed at slopes of 10°, 15°, and 20° to the horizontal.

Expansion. Use result B and find values for e e^2 e^3 $e^{\frac{1}{2}}$ e^{π} and $\frac{1}{2}e\pi$ Make a table showing these results, their logs the logs of their reciprocals and their reciprocals Work to four places of decimals

Solutions to Problems in Lesson 30.

Drill 1 Use the cosine rule to find BC = 5·2, CD = 5·5; BD = 4·6 For area of ABC use $\frac{1}{2}$BA AC sin70, and so on Area ABC = 9·4, CAD = 7·5, DAB = 8 For area BCD use the "s−" rule Area BCD = 11·1 Total 36 square units

Revision 1. Let $x - y = a$ and $x^3 - y^3 = b$, then $x^2+xy+y^2 = b/a$, $xy = (b - a^3)/3a$, $(x + y)^2 = \frac{4b}{3a} - \frac{a^2}{3}$;

$$x=\tfrac{1}{2}\left(a \pm \sqrt{\frac{4b}{3a}-\frac{a^2}{3}}\right)$$

Substituting $x=\frac{1}{2}(3 \pm 7)$, i.e. $x=5$ or -2, $y=2$ or -5

2 (i) Let $(x+3)=m$, $(y-2)=n$, then $m^3-n^3=40$ and $m-n=2$, whence $m=1\pm\frac{1}{2}\sqrt{19}$ and $n=-1\pm\frac{1}{2}\sqrt{19}$, whence $x=-2\pm\frac{1}{2}\sqrt{19}$, and $y=1\pm\frac{1}{2}\sqrt{19}$

(ii) Let $X=x-n$ and $Y=y+p$, then $X^3-Y^3=a$ and $X-Y=b-n-p$, whence $X=\frac{1}{2}\left(a\pm\sqrt{\frac{4(b-n-p)}{3a}-\frac{a^2}{3}}\right)$, whence

$$x=\tfrac{1}{2}\left(a+2n\pm\sqrt{\frac{4(b-n-p)}{3a}-\frac{a^2}{3}}\right) \text{ and } y =$$

$$\tfrac{1}{2}\left(-a-2p\pm\sqrt{\frac{4(b-n-p)}{3a}-\frac{a^2}{3}}\right); \text{ whence, 3,}$$

$x=5$ or -2, $z=-2$ or 5 (Note the order.)

Expansion Vol. of tetrahedron of edge $x=\frac{1}{12}\sqrt{2}\,x^3$ Stepping down from this *once*, we get $\frac{1}{4}\sqrt{2}\,x^2$, *twice*, $\frac{1}{2}\sqrt{2}\,x$, *three times*, $\frac{1}{2}\sqrt{2}$ Of these expressions $\frac{1}{2}\sqrt{2}\,x$ is the edge of the enclosing cube, hence the constant for which we search might be $\sqrt{2}$, the relation between the side of a square and its diagonal, which we have already symbolized as "S" But the investigation is complicated by the figure 3 for 3 has a double significance:

(*a*) a numerical 3 belonging to the stepping down from volumes to areas, and (*b*) a value $\sqrt{3}$ due to the equilateral shape of the faces of the tetrahedron. This suggests that the constant we require is $\sqrt{2}\sqrt{3}=\sqrt{6}$, so that T = " SE ", on this scale, the tetrahedral scale, this constant T gives the following formulas: Tetrahedral formulas in terms of a constant T when the edge is x Area of one face $= \frac{1}{8}\sqrt{2}Tx^2$, surface area $= \frac{1}{2}\sqrt{2}Tx^2$, height $= \frac{1}{3}Tx$, volume $= \frac{1}{36}\sqrt{3}Tx^3$; spherical radii, circum $= \frac{1}{4}Tx$; in $= \frac{1}{12}Tx$, midside $\frac{1}{12}\sqrt{3}Tx$

Compared with the corresponding values for a cube, these results give this interesting table

Given the edge of a tetrahedron = x, the edge of the enclosing cube $= \sqrt{2}x = \frac{1}{6}\sqrt{3}Tx$.

Values of	Cube	Tetrahedron	Ratios
Area of one face	$\frac{1}{12}\sqrt{6}Tx^2$	$\frac{1}{8}\sqrt{2}Tx^2$	$\frac{1}{2}\sqrt{3}=\frac{1}{4}\sqrt{2}T$
Area of surface	$\frac{1}{2}\sqrt{6}Tx^2$	$\frac{1}{2}\sqrt{2}Tx^2$	$\frac{1}{3}\sqrt{3}=\frac{1}{6}\sqrt{2}T$
Volume ...	$\frac{1}{12}\sqrt{3}Tx^3$	$\frac{1}{36}\sqrt{3}Tx^3$	$\frac{1}{3}=\frac{1}{18}\sqrt{6}T$
Height ...	$\frac{1}{6}\sqrt{3}Tx$	$\frac{1}{3}Tx$	$\frac{2}{3}\sqrt{3}=\frac{1}{3}\sqrt{2}T$
Radii " circum "	$\frac{1}{4}Tx$	$\frac{1}{4}Tx$	$1=\frac{1}{6}\sqrt{6}T$
„ " in " ...	$\frac{1}{12}\sqrt{3}Tx$	$\frac{1}{12}Tx$	$\frac{1}{3}\sqrt{3}=\frac{1}{6}\sqrt{2}T$
„ " mid-side "	$\frac{1}{12}\sqrt{6}Tx$	$\frac{1}{12}\sqrt{3}Tx$	$\frac{1}{2}\sqrt{2}=\frac{1}{6}\sqrt{3}T$

$\sqrt{2}T = ST = S^2E$; $\sqrt{3}T = ET = SE^2$; $\sqrt{6}T = T^2 = S^2E^2$.

LESSON 32

On Logarithms

COMMON logarithms are the indices of 10; Napierian logarithms are the indices of e. 10 is the base of common logarithms; e is the base of Napierian logarithms. Logarithms are a device for the substitution of multiplication for addition.

$$e = \left(1 + \frac{1}{n}\right)^n$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \frac{x^5}{5!} \text{ etc.}$$

$$e = 2{\cdot}7182818\ldots\ldots\ldots$$

From which it has been calculated (*see* Expansion, Lesson 31, and below) that $e^2 = 7{\cdot}3891$, which may be written $\log_e 7{\cdot}3891 = 2$; and, similarly from the table below:

$$\log_e 2{\cdot}7183 = 1;\ \log_e 0{\cdot}3679 = -1;\ \log_e 0{\cdot}1353 = -2;$$
$$\log_e 20{\cdot}0855 = 3;\ \log_e 0{\cdot}0498 = -3;\ \log_e 54{\cdot}5982 = 4;$$
$$\log_e 0{\cdot}0183 = -4,\ \log_e 23{\cdot}1407 = \pi;\ \log_e 0{\cdot}0432 = -\pi;$$
$$\log_e 4{\cdot}8105 = \tfrac{1}{2}\pi;\ \log_e 0{\cdot}2079 = -\tfrac{1}{2}\pi.$$
$$a^{bx} = 1 + bx \log_e a + \frac{(bx \log_e a)^2}{2!} + \frac{(bx \log_e a)^3}{3!} \text{ etc.}$$

In this expression, write $(1 + x)$ instead of a and c instead of bx; then

$$(1 + x)^c = 1 + c \log_e (1 + x) + \frac{c^2 \log_e (1 + x)^2}{2!} \text{ etc.}$$

$$\text{But } (1 + x)^c = 1 + cx + \frac{c(c-1)}{2!}x^2 + \frac{c(c-1)(c-2)}{3!}x^3 \text{ etc.}$$

on the condition that x is less than 1.

This last expression may be rearranged in reference to c in this manner:

$$(1 + x)^c = 1 + c\left(x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4}\ldots\ldots\ldots\right.$$
$$\left. + c^2\left(\frac{x^2}{2} - \frac{x^3}{2}\ldots\ldots\ldots\right) + c^3\left(\frac{x^3}{3!}\ldots\ldots\ldots\ldots\right)\right)$$

Since x is less than 1, the coefficients of c are equal, so that

$$\log_e (1 + x)^c = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4} + \frac{x^5}{5} - \frac{x^6}{6}\ldots\ldots\ldots\ldots$$

This is result E—another result to be memorized.

This result is used in the calculation of Napierian logarithms. If $x = \frac{1}{2}$, then $\log_e \frac{3}{2} = \log 3 - \log 2 = \frac{1}{2} - \frac{1}{2}(\frac{1}{2})^2 + \frac{1}{3}(\frac{1}{2})^3 - \frac{1}{4}(\frac{1}{2})^4 \ldots$

the positive terms		*the negative terms*	
$\frac{1}{2}$	$= 0{\cdot}5$	$\frac{1}{2}(\frac{1}{2})^2$	$= 0{\cdot}125$
$\frac{1}{3}(\frac{1}{2})^3$	$= 0{\cdot}041667$	$\frac{1}{4}(\frac{1}{2})^4$	$= 0{\cdot}015625$
$\frac{1}{5}(\frac{1}{2})^5$	$= 0{\cdot}006250$	$\frac{1}{6}(\frac{1}{2})^6$	$= 0{\cdot}002604$

$\frac{1}{7}(\frac{1}{2})^7 = 0{\cdot}001116$	$\frac{1}{8}(\frac{1}{2})^8 = 0{\cdot}000488$
$\frac{1}{9}(\frac{1}{2})^9 = 0{\cdot}000217$	$\frac{1}{10}(\frac{1}{2})^{10} = 0{\cdot}000098$
$\frac{1}{11}(\frac{1}{2})^{11} = 0{\cdot}000043$	$\frac{1}{12}(\frac{1}{2})^{12} = 0{\cdot}000020$
$\frac{1}{13}(\frac{1}{2})^{13} = 0{\cdot}000009$	$\frac{1}{14}(\frac{1}{2})^{14} = 0{\cdot}000005$
$0{\cdot}549302$	$0{\cdot}143840$

difference $= 0{\cdot}4055$ (approx.)

Similarly, by taking $x = \frac{1}{3}$

$\log_e 4 - \log_e 3 = 2 \log_2 2 - \log_2 3 = 0{\cdot}2877$

Combining these results, we get

$\log_e 2 = 0{\cdot}6932$ and $\log_e 3 = 1{\cdot}0987$

Whence we deduce that $\log_e 4 = 1{\cdot}3864$, $\log_e 8 = 2{\cdot}0796$,

$\log_e 6 = 1{\cdot}7919$ $\log_e 9 = 2{\cdot}1874$ and so on.

These results are inaccurate for the fourth figure; more correct results may be obtained by taking the difference as $0{\cdot}40546$.

Obviously, such calculations are tedious.

Since $\log_e (1 + x) = x - \frac{x^2}{2} + \frac{x^3}{3} - \frac{x^4}{4}\ldots\ldots\ldots\ldots$

then $\log_e (1 - x) = - x - \frac{x^2}{2} - \frac{x^3}{3} - \frac{x^4}{4}\ldots\ldots\ldots\ldots$

whence $\log_e \frac{(1 + x)}{(1 - x)} = 2(x + \frac{x^3}{3} + \frac{x^5}{5} + \frac{x^7}{7}\ldots\ldots\ldots\ldots)$

Whence if $x = \frac{1}{4}$, $\log_e \frac{(1 + x)}{(1 - x)} = \log_e 5 - \log_e 3$

$$= 2 \left\{\begin{matrix} 0{\cdot}25 \\ 0{\cdot}0052083 \\ 0{\cdot}0001953 \\ 0{\cdot}0000087 \\ 0{\cdot}0000004 \end{matrix}\right\} = 2(0{\cdot}2554137) = 0{\cdot}5108274$$

But $\log_e 3 = 1{\cdot}098612$

so $\log_e 5 = 1{\cdot}609439$

and $\log_e 2 = 0{\cdot}693147$

so $\log_e 10 = 2{\cdot}302585$

whence, by division, the reciprocal of $\log 10 = 0{\cdot}434294 = \mu$, but

$\log_{10} N = \dfrac{\log_e N}{\log_e 10} = \dfrac{\log_e N}{2.302585} = \log_e N(0{\cdot}434294)$, whence, to change a logarithm from base e to base 10, multiply by (0·434294), which is called the modulus of the common system of logarithms; e.g. 1·6094 times 0·4343 = 0·6990 = $\log_{10} 5$.

If $x = \dfrac{1}{2N+1}$ then $\dfrac{N+1}{N} = \dfrac{(1+x)}{(1-x)}$

whence $\log_e \dfrac{N+1}{N} =$

$$2\left(\frac{1}{2N+1} + \frac{1}{3(2N+1)^3} + \frac{1}{5(2N+1)^5}\ldots\ldots\right)$$

whence $\log_{10} \dfrac{N+1}{N} =$

$$2\mu\left(\frac{1}{2N+1} + \frac{1}{3(2N+1)^3}\ldots\ldots\ldots\right)$$

Let N = 100, then $\dfrac{N+1}{N} = 1{\cdot}01$

$\log_{10} 100 = 2,$

$$\begin{aligned}\log_{10} 1{\cdot}01 &= 2\mu\left(\frac{1}{201} + \frac{1}{3(8120601)}\ \ldots\ldots\ldots\right)\\ &= \frac{0{\cdot}43429}{100{\cdot}5} + \frac{0{\cdot}43429}{12180901{\cdot}5}\ \ldots\ldots\ldots\ldots\\ &= 0{\cdot}004321\,34 + 0{\cdot}00000004\\ &= 0{\cdot}00432138\end{aligned}$$

$\dfrac{N+1}{N}$	N	$\dfrac{1}{2N+1}$	Difference between successive terms
1.01	100/1	1/201	200/(202·201)
1.02	100/2	2/202	200/(202·201)
1.03	100/3	3/203	200/(203·202)
1·06	100/6	6/206	
1·07	100/7	7/207	200/(207.206)

The above table disregards the terms $\dfrac{1}{3(2N+1)^3}$ etc., since they are not likely to affect the first four significant figures

log 1·01 = $2\mu(1/201)$ = 0·004321.

The jump from log 1.01 to log 1.02

$= 2\mu(200/202.201)$

$$= 0.004321(200/202)$$
$$= 0.004278$$

$\log 1{\cdot}02 = 0{\cdot}004321 + 0{\cdot}004278 = 0{\cdot}008599 = 0.0086$

The next jump, similarly $= 2\mu(200/203.202)$
$$= 2\mu(2/202) \text{ times } 100/203$$
$$= 0{\cdot}008599 \text{ times } 100/203$$
$$= 0{\cdot}004236$$

$\log\ 1{\cdot}03 = 0{\cdot}008599 + 0{\cdot}004236 = 0{\cdot}012835 = 0{\cdot}0128$

The logarithms are correct to four significant figures.

$\log 1{\cdot}06 = 2\mu(6/206) = 0{\cdot}025288 = 0{\cdot}0253$,

hence $\log 1{\cdot}07 = \log 1{\cdot}06 + \log 1{\cdot}06 \text{ times } 200/(6{\cdot}207)$

$= 0{\cdot}025288 + 0{\cdot}025288 \text{ times } 100/621$

$= 0{\cdot}025288 + 0{\cdot}00407$

$= 0{\cdot}0294$; which is correct to four figures. In this manner, the whole of the customary printed four-figure logarithmic table could be constructed; the process would be so lengthy that it is worth while to have these tables calculated once for all.

The computation of the reciprocal or antilogarithmic tables is a similar tedious process which, once done, is done for always. These logarithmic tables, either to base 10 or to base e, are but convenient scales on which calculations may be simply made. Their use is fairly simple, but their theoretical basis and their computation require more comprehensive knowledge; hence many students are able to use the scales without comprehending how they came into being or why they are accurate They thus become a tool for the use of the practical man.

The process of reciprocity has arithmetical significance in relation to contractors' estimates of the composition of their teams of man-power with reference to the completion of jobs within specified periods.

It is assumed that A units of power, i.e. men or navvies, who can do a job in N days, do 1/N of the job per day, and that 1 man will do 1/AN of the job per day.

If 3 men will do a job in 5 days and 7 men will do the same job in 2 days, it does not follow that 10 men will do the job in 7 days, nor does it follow that 10 men will do the job in $3\frac{1}{2}$ days, or in $2\frac{1}{2}$ days, or in 1 day; the process of compounding the two teams involves a mental step which is not recorded in the arithmetical code. The first team does 1/5 of the job per day, the second team does $\frac{1}{2}$ the job per day; both teams would do 7/10 of the job

per day; hence both teams together would complete the job in 10/7, i.e. $1\frac{3}{7}$ days. It will be obvious that the assumption that one man's work per day is a constant quantity and is equal to any other man's work for a day is not satisfied. A man in the first team does on the average for the three men, as well as on the average for the five days, a constant piece of work, which is measured as 1/15 of the job; similarly, a man in the second team is rated at, on the average, 1/14 of the job. These assumptions must be made or no calculation at all would be possible; hence computed values of this character are very approximately true.

If two men A and B can together complete a job in $4\frac{1}{2}$ days, and B and C can complete the job in $4\frac{1}{4}$ days, and C and A can complete the job in $4\frac{3}{4}$ days; then the daily doses of labour are 2/9, 4/17 and 4/19. Hence twice the work of the three men per day comes to the total of these fractions, which is 1942/2907, and the three together would do the job in, roughly, three days. By computation they would take $2\frac{965}{971}$ days. Working in 1/2907 of the job, A and B do per day 646, A and B and C do 971, hence C would do 325; similarly, A would do 287, and B 359. These are the relative ratings of the three men, so that B appears to be 25% more capable than A. Another form of the rating is to say that to complete the job working alone A would take $10\frac{37}{287}$ days, B $8\frac{35}{359}$ days, C $9\frac{82}{325}$ days.

Drill. 1. Calculate logs 27, 28, and 29. Check the result by the tables.

2. Given log 5000 = 3·6990; calculate log 5001, 5002, etc. Check the result against the different values in the log tables.

3. If A and B could do a job in 16 days, B and C in $16\frac{1}{2}$ days, and C and A in 17 days: find a rating for the relative abilities of A and B and C, and make up the best team of men at these three ratings capable of doing the job in a day.

Revision. 1. Show that the common chord of two intersecting circles is bisected at right angles by the line of centres of the circles.

2. Draw the four tangents common to two circles which do not touch or intersect. Find the properties of these tangents. Given the radii of the circles as R and r and the distance between the centres of the circles as D, find the lengths of the portions of the tangents between the points of contact with the circles.

Expansion. A hollow sphere has a thickness T and an internal diameter D. Find an expression for the ratio between the volume of the solid thickness in terms of the internal emptiness.

If D be taken as 100 cm., find values for the volume of the thickness when the thickness is 1 cm., and for the increases in volume when the thicknesses increase from 1 to 2, 3, etc.

Give the answers as decimal fractions of the internal volume.

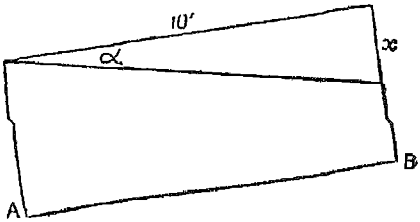
Solutions to Exercises in Lesson 31.

Drill.

n	n !	log n !	$\log \frac{1}{n!}$	$\frac{1}{n!}$
11	39 916 800	7 6012	8.3988	0.0000 0002505211
12	479 001 600	8 6803	9.3197	0 0000 0000208768
13	6 227 020 800	9 7043	10 2057	0 0000 0000016059
14	87 178 291 200	10 9404	11 0596	0 0000 0000001147
15	1 307 674 368 000	12 1165	13 8835	0 0000 0000000077

Revision 200 cu. ft. = 1245 gallons.

In the Fig. let α = the angle of slope, then $x = 10 \tan \alpha$;



area lost = $5x = 50 \tan \alpha$; reduction in capacity $(50 \tan \alpha)/40$

i.e. when α = 10 reduction = 0·22 = 22%

15 0·33 = 33%

20 0·455 = 45½%

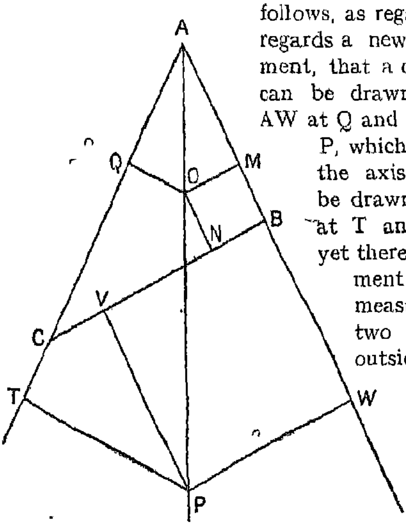
Expansion.

	Numerical value	Log	Log reciprocal	Reciprocal
e	2·7183	0·4343	$\bar{1}$·5657	0·3679
e^2	7·3891	0·8686	$\bar{1}$·1314	0·1353
e^3	20·0855	1·3029	$\bar{2}$·6971	0·0498
e^4	54·5982	1·7372	$\bar{2}$·2628	0·0183
e^{π}	23·1407	1·3644	$\bar{2}$·6356	0·0432
$e^{\frac{1}{2}\pi}$	4·8105	0·6822	$\bar{1}$·3178	0·2079

LESSON 33

More About the Triangle

A TRIANGLE is a figure; hence it is determined by two dimensional measurements. A triangle is fixed when its base is fixed and the position of its vertex relative to this base is fixed, there can be only one triangle on one base with its vertex at one point. In the accompanying figure we start with a vertex at A and an axis of symmetry of indefinite length AP; AT and AW are two lines set symmetrically to AP, this fact provides a measurement in one dimension, i.e., the angles PAW and PAT are equal. In AP any point O is taken, and it follows, as regards shape but not as regards a new dimensional measurement, that a circle with O as centre can be drawn to touch AT and AW at Q and M respectively. From P, which is any other point in the axis, a similar circle can be drawn to touch AT and AW at T and W respectively; as yet there is no second measurement. Let OP be a second measurement such that the two circles lie completely outside each other, which is a condition of shape; then OP is a second dimension. Draw BC to touch the two circles at N and V respectively, so that AC > AB.



ABC is a triangle—a unique triangle, for there is only one line BC which will fit the conditions laid down as to shape. It is required to determine the triangle in terms of the two given fixed measurements, angle PAW $=\frac{1}{2}A=\theta$; and length OP $=$ D. Using

the a, b, c code for the lengths of the sides of ABC and s for the semi-perimeter of ABC, it follows that

AT = AW = s

AM = AQ = (s − a), BM = BN = CV = CT = (s − b), CQ = CN = BV = BW = (s − c)

MW = QT = BC = a

NV = a − 2(s − b) = (b − c)

$$OM = ON = OQ = r = \sqrt{\frac{1}{s}(s-a)\ (s-b)\ (s-c)}$$

$$PT = PW = PV = R = \sqrt{\frac{1}{(s-a)}s(s-b)\ (s-c)}$$

All these facts are dependent upon the constructed shape, and are relative to each other, but as yet of no dimensional value in the given figure since they are not referred to the fixed dimensions θ and D

Similarly using the general code for angles, A, B C,

PAW = PAT = ½A, NOP = OPV ½B − ½C, AOQ = AOM = APT = APW = ½B + ½C VPT = C, QON = A + B QOP = 90° − ½A VPW = B

Combining the codes and still keeping to generalizations due to the given shape it follows that

$$\text{since } \tfrac{1}{2}(1-\cos A) = \frac{1}{bc}(s-b)\ (s-c),$$

$$\sin \tfrac{1}{2} A = \sqrt{\frac{(s-b)\ (s-c)}{bc}}$$

$$\text{since } \tfrac{1}{2}(1+\cos A) = \frac{1}{bc}s\ (s-a),\ \cos \tfrac{1}{2}A = \sqrt{\frac{s(s-a)}{bc}};\ \tan \tfrac{1}{2}A = \sqrt{\frac{(s-b)\ (s-c)}{s(s-a)}}$$

Since b/c = sin B/sin C, (b ± c)/c = (sin B ± sin C)/sin C; (b − c)/(b + c) = (sin B − sin C)/(sin B + sin C) = (tan ½B − ½C)/(tan ½B + ½C) = (tan ½B − ½C)/cot ½A

tan ½(B − C) =

$$\left(\sqrt{s(s-a)\ (s-b)\ (s-c)}\right)\ (b-c)/(b+c)$$

There is still another general relation Since PBO and PCO are right angles, the circle with OP as diameter cuts AW at B and AT at C

Applying the general facts to the particulars given, i e, $\frac{1}{2}A=\theta$ and $OP=D$, it follows that $a=D\cos\theta$ Hence the particulars given suffice to fix only the length of the base of the required triangle, and are, therefore, insufficient to fix the triangle completely.

If BC be considered as the fixed base so set in position A may occur anywhere upon the larger arc of the circum-circle of the triangle ABC, i e A is not fixed in position in reference to the position BC

If TAW be considered as the fixed position then, so long as OP is constant in size, it may happen anywhere along the axis of symmetry, and will for each position yield two bases for the triangle, these bases can be obtained by cross-joining the points at which the circle with OP as diameter cuts AW and AT

To determine a triangle it is, therefore, necessary to fix precise information which will determine b or c, for since $(b-c)$ occurs in the figure, if either b or c is given, then c or b can be determined Similarly, since $\frac{1}{2}A=\theta$, A is known, if B or C be given, then the shape of the triangle is known, and the triangle of given shape on a given base is fixed The data given yield an indeterminate solution

Since $e^x=1+x+\frac{x^2}{2!}+\frac{x^3}{3!}+\frac{x^4}{4!}$ etc

$$\frac{d}{dx}(e^x)=0+1+x+\frac{x}{2!}+\frac{x^2}{3}+\frac{x^4}{4!}\text{ etc.}$$
$$=e^x$$

The differential coefficient of e^x is e^x This statement is the *law of compound interest*

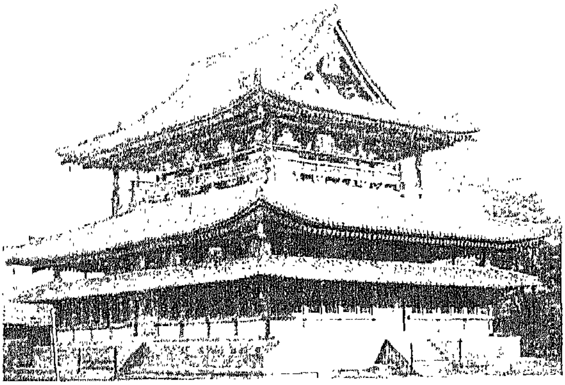
A principal P at 1% compound interest per annum in t years yields an amount A, then $A/P=\left(1+\frac{1}{100}\right)^t$

If the unit of time be $nr/100$ when n is very large then AP=

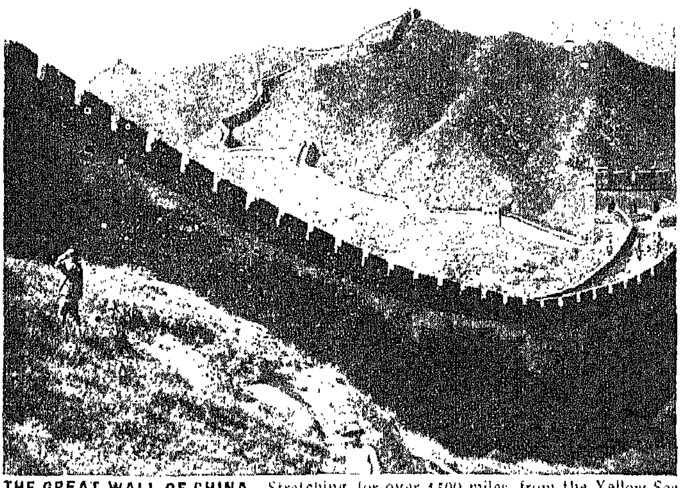
$$\left(\left(1+\frac{1}{n}\right)^n\right)_{\frac{rt}{100}}=e^{\frac{rt}{100}}$$

but P may be taken as £1, then £$A=e_{\frac{rt}{100}}$ whence amounts at compound interest should be read from tables of Napierian logarithms

Since $\log_e 2=0\ 693$, then the product of the rate % and the time in years in which money at compound interest should double

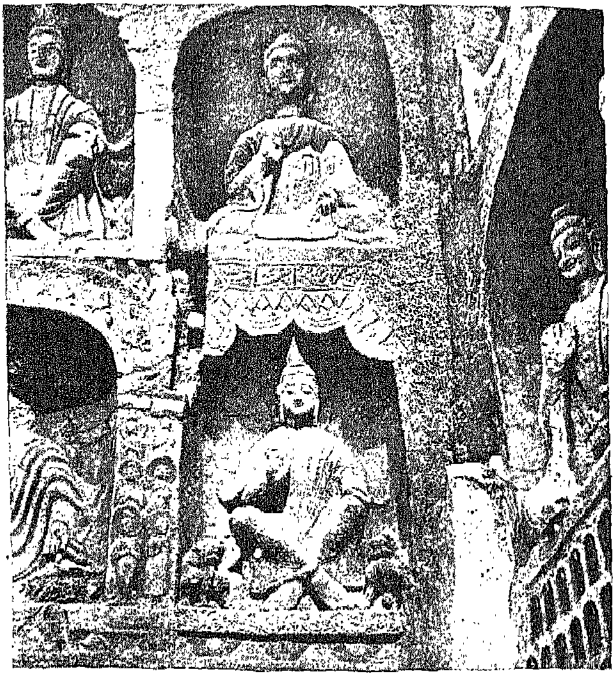


JAPAN'S OLDEST BUDDHIST TEMPLE. Buddhism was introduced into Japan in A.D. 552, about the time Christianity was brought to England, and within a century and a half it became the state religion. The temple shown above is that at Horyuji, founded about A.D. 600.
HISTORY: ANCIENT 26
Photo, E.N.A.



THE GREAT WALL OF CHINA. Stretching for over 1500 miles, from the Yellow Sea to the borders of Kansu and Chinese Turkestan, the Great Wall of China dates from the 3rd century B.C. and was designed as a defence against the nomad Huns to the west. For fifteen years the labour power of the Empire was mobilized for the task. Many thousands of square battlemented towers are distributed throughout its length. Towards its western end the wall has crumbled into ruin, but elsewhere, as may be seen from the photo, it has been kept in good repair. HISTORY: ANCIENT 26
Photo, E.N.A.

SAGES OF CHINA. Confucius (551–478 B.C.) held various government posts, but spent most of his years in teaching and in the elaboration of a code of good behaviour. Right, Mencius (c. 372–289 B.C.), the most famous of his disciples. HISTORY: ANCIENT 26



BUDDHISM IN CHINA. The introduction of Buddhism into China was responsible for the growth of a new type of art in which Indian influence is apparent. It can be seen in the numerous Buddhas and other inmates of the Mahayanist pantheon carved under the Toba Tatars in the grottoes of Yün-kang, from A.D. 400 onwards. HISTORY: ANCIENT 26

From Chavannes, "Mission archéologique dans la Chine septentrionale"

itself should be 69 3, i e at 4%, 17 3 years, at 10%, 6 93 years This is an ideal figure toward which the values obtained in commercial calculations should approach For example the time for a principal to double itself at 20%, reckoned annually, working in logs =0 3010/0 0792 =3 80 reckoned six-monthly, =0 3010/0 0414 =7 27, i e 3 64 years, reckoned three monthly, = 0 3010/0 0212 — 14 2, i e 3 55 years, reckoned monthly, = 0 3010/0 0107 = 41 8 i e 3 48 years These values converge towards 3 46 years The respective divisors in the computations steadily increase relative to 0 3010 Hence 3 46 years is the time for a principal to double itself when the C I is reckoned at short intervals such as weekly or daily

Since log 3 — 1 099 money will treble itself at C I when the product of the rate % and the time is not less than 1 099, i e at 3% C I p a in just about 37 years

Speeds. Unit speed is unit distance in unit time Scales of speeds are reckoned in miles per hour, feet or centimetres per second and so on When velocities are very great such as the speed of light, which exceeds 300 million yards a second we use the distance traversed by light in a year as a unit of distance, and say that the nearest stars are x light years from the earth, where x is in the neighbourhood of 5 The speed of light is sometimes taken as a constant c = 186,000 miles a second When a body moves A units of distance in B units of time, its speed S is S units of distance in unit time and Sk miles per hour Sm kilometres per hour Sn yards per second, and so on, where k and m and n are constants dependent on the units of measurement roughly, 5 miles per hour is the same speed as 8 kilometres per hour and 7½ m p h is the same speed as a furlong a minute

The speed S m p h =A/B m p h =B/A hours per mile The speed (S + 1) m p h =(A + B)/B m p h =B/(A + B) hours per mile Hence, when the speed in m p h is increased by 1, i e by 1/S of the original speed A/B is increased by B/B and times in hours per mile are decreased by B/(A + B) of the original time per mile, e g if a speed of 23/7 m p h is increased by 1 m p h A = 23, B = 7 The new speed = 30/7 m p h, and has been increased by 7/23 of the original miles per hour, it is also 7/30 hours per mile, having decreased from 7/23 hours per mile The decrease is 7/23-7/30 = 49/690 hours per mile, which is 7/30 of the original hours per mile

The following table shows these relations when a speed of 5 m.p.h. is successively improved over successive miles by 5 m.p.h.

Miles	1st	2nd	3rd	4th	5th	Hours
Speed m.p.h.	5	10	15	20	25	Speed h.p.m.
Fractional increase	...	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	Fractional increase
Speed h.p.m.	$\frac{1}{5}$	$\frac{1}{10}$	$\frac{1}{15}$	$\frac{1}{20}$	$\frac{1}{25}$	Speed m.p.h.
Fractional decrease	...	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$	Fractional decrease

The fractional increases and decreases shown in the table are each calculated on the speed for the previous mile. If miles be changed to hours, as on the right of the table, the numerical values within the table hold, with the appropriate changes in the labels as shown on the right-hand side. Thus, if a speed is doubled, the time taken is decreased by half of what it was; if the speed be trebled, the time taken is decreased by $\frac{2}{3}$ of what it was, if the speed be increased by 10%, the time is decreased from 1/10 to 1/11, i.e. by 1/110, 1/11 of what it was.

Drill 1. A train takes 15 minutes longer to do a journey at 25 m.p.h. than at 30 m.p.h. : how long is the journey?

2. A train travelling uniformly between two stations 60 miles apart lost time on its journey, and was 5 minutes late passing the second station. Had the train's speed been 50 miles an hour it would have been 17 minutes late. At what speed did the train travel? What was its normal speed!

3. Solve the triangle ABC in the figure in p. 478, when OP = 6 in., A = 60° and AP cuts CB at an angle of 54°.

Revision 1. A train's speed is 40 m.p.h. (a) What is its speed in feet per second? (b) How long will it take, if it is 66 yards in length, to pass completely a signal post? (c) To cross completely a bridge 110 yards long? (d) To pass completely a man walking by the side of the line at 4 m.p.h. (i) in the same direction, (ii) in the opposite direction? (e) To pass completely a train 88 yards long and travelling at 30 miles an hour (i) approaching, (ii) going in the same direction?

2. Use the figure in p. 478 and completely solve the triangle, given that A = 40° B-C = 10° and b-c = 1 inch.

Expansion 1. Draw the graph of $x^2+y^2=25$, and determine the equations of the tangents to the circles at the points when $x=3$ and $y=\sqrt{5}$.

2. Draw the graph of $y=3x^2-6$. Draw the tangents to the curve at the points where $y=12$ and $y=0$. Give the equations of these lines as well as you can from your drawings.

Solutions to Exercises in Lesson 32.

Drill 1. 1·4314, 1·4472, 1·4624. 3. The job is to do $16.17.33=$ 8976 in a day $A=545$, $B=577$, $C=511$. 8A and 8B would make a team

Revision 1. The line of centres is an axis of symmetry, and the intersections of the circles are symmetrically placed. 2. See figure in page 478.

Expansion. $\dfrac{\text{Vol. of thickness}}{\text{Internal vol}}=\dfrac{(D+2T)^3-D^3}{D^3}$

Internal vol. $=\dfrac{\pi}{6}=0.5236$ cubic metres.

$T=1$ Fraction $=0·061208$, $T=2$ Fraction $=0·124864$. $T=3$ Fraction $=0·191016$. Answer $=0·5236\times0·061208$; etc.

Look up the difference between C.I. and S.I., etc., for 3 years in your references.

LESSON 34

Properties of an Isosceles Triangle

An isosceles triangle is symmetrical about the bisector of the vertical angle in Fig. 1 ABC is isosceles symmetrical about BK

Hence AB = AC, AK = KC, angle BAK = angle BCK.

One of the equal sides BC is produced to D so that CD = CB.

AD is drawn and BK produced to cut AD at E It is required to determine the ratio between BK and KE.

Produce AC to meet DM drawn parallel to BK at M.

AK = KC = CM, hence MD = 3KE. But MD = BK.

Hence BK = 3KE

If CD = 2CB, then CM = 2CK and MD = 2BK; also AK $\frac{1}{4}$AM, and KE = $\frac{1}{4}$MD, whence BK = 2KE.

Generally, if CD = n times CB, then MD = n.BK.
CM = n.AK; i.e. AM = (n+2) AK.
Whence MD = (n+2).KE and BK = KE times (n+2)/n.
Trigonometrically, if BAC = α and CAD = β, then tan α /tan β = BK/KE = (n+2)/n.

In Fig. 2 the side CB of the isosceles triangle is produced in the other direction to D so that BD = m.BC. It is required to determine the ratio of AM to MC. AM = KC − KM = (1−m) KC.

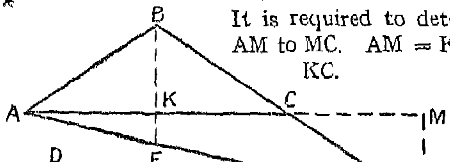


Fig. 1

MC = KC + KM = (1+m) KC; whence AM/MC = (1−m) /(1+m)

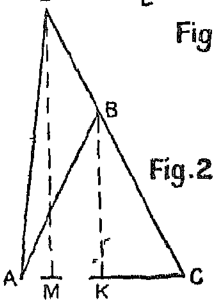


Fig. 2

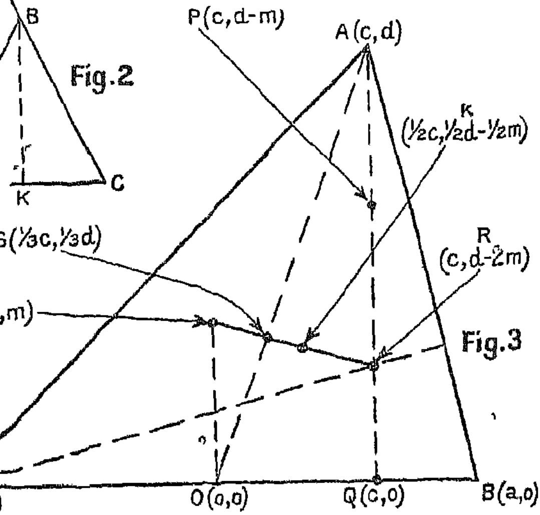


Fig. 3

Whence, when BCA = α and DAC = β, tan α /tan β = (1−m) /(1+m)

Let points B (a, O), C(−a, O) and S (O, m) be such that a and m may have any value. With centres in OS many circles may be drawn with C and B on their circumferences. Of these numerous

circles one only will have the point A (c, d) on its circumference, and its centre at S

The equation of this circle is

$$x^2 + y^2 - 2my = a^2$$

and the condition that it passes through the point A is that $a^2 - c^2 = d^2 - 2md$

The equation of the line AB is $dx + (a - c)y = ad$

From C a perpendicular is dropped to AB, cutting the perpendicular from A to BC at R.

The equation of AR is $x - c = O$

that of CR, because it is perpendicular to AB,

$$(a - c)x - dy = ac - a^2$$

From these equations R is the point

$$\left(c, \frac{a^2 - c^2}{d}\right)$$

Since $a^2 - c^2 = d^2 - 2md$, another statement for R is $(c, d - 2m)$, whence it follows that the length of AR is 2m.

The equation of the line SR is obtained from the values of S and R, and is

$$(3m - d)x + cy = cm$$

The equation of the line from A through the origin is $dx - cy = O$

From these two equations it is found that G, the point where the lines SR and AO intersect, is $(\frac{1}{3}c, \frac{1}{3}d)$, whence it follows that OG is a third of OA.

The point K is the mid-point of SR and is $(\frac{1}{2}c, \frac{1}{2}d - \frac{1}{2}m)$

The equation of the circle with centre K and radius OK is $x^2 - cx + y^2 - (d - m)y = O$

This circle cuts the line (AB) $x - c = O$ at the points indicated by the solution of the equation $y^2 - (d - m)y = O$; i.e. when $y = O$ and when $y = (d - m)$

But $y = O$ at Q, where AR meets BC, and $y = (d - m)$ at P, which is midway between A and R, hence OP is a diameter of this circle.

The radius of the circle, centre S, is $\sqrt{m^2 + a^2}$

The radius of the smaller circle, centre K, is $\frac{1}{2}\sqrt{c^2 + (d - m)^2}$, which is equal to $\frac{1}{2}\sqrt{m^2 + a^2}$

These results may now be transferred from the code of coordinate geometry to the code of ordinary plane geometry.

ABC is any triangle.

Generally, if CD = n times CB, then MD = n.BK.
CM = n.AK; i.e. AM = (n+2) AK.

Whence MD = (n+2).KE and BK = KE times (n+2)/n.

Trigonometrically, if BAC = α and CAD = β, then $\tan\alpha/\tan\beta$ = BK/KE = (n+2)/n

In Fig. 2 the side CB of the isosceles triangle is produced in the other direction to D so that BD = m.BC. It is required to determine the ratio of AM to MC. AM = KC − KM = (1−m) KC.

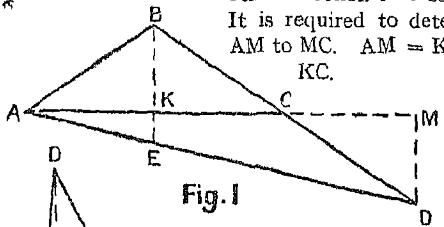


Fig. I

MC = KC + KM = (1+m) KC; whence AM/MC = (1−m)/(1+m)

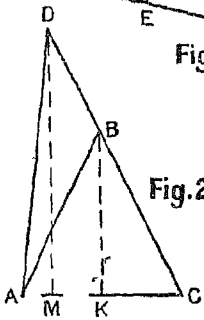


Fig. 2

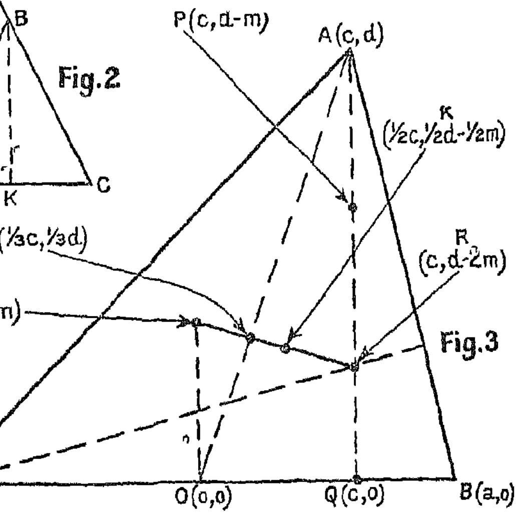


Fig. 3

Whence, when BCA = α and DAC = β, $\tan\alpha/\tan\beta$ = (1−m)/(1+m)

Let points B (a, O), C(−a, O) and S (O, m) be such that a and m may have any value. With centres in OS many circles may be drawn with C and B on their circumferences. Of these numerous

circles one only will have the point A (c, d) on its circumference, and its centre at S

The equation of this circle is

$$x^2 + y^2 - 2my = a^2$$

and the condition that it passes through the point A is that $a^2 - c^2 = d^2 - 2md$

The equation of the line AB is $dx + (a - c)y = ad$

From C a perpendicular is dropped to AB, cutting the perpendicular from A to BC at R

The equation of AR is $x - c = O$

that of CR because it is perpendicular to AB,

$$(a - c)x - dy = ac - a^2$$

From these equations R is the point

$$\left(c, \frac{a^2 - c^2}{d}\right)$$

Since $a^2 - c^2 = d^2 - 2md$, another statement for R is $(c, d - 2m)$, whence it follows that the length of AR is $2m$

The equation of the line SR is obtained from the values of S and R, and is

$$(3m - d)x + cy = cm$$

The equation of the line from A through the origin is $dx - cy = O$

From these two equations it is found that G, the point where the lines SR and AO intersect, is $(\frac{1}{3}c, \frac{1}{3}d)$, whence it follows that OG is a third of OA

The point K is the mid-point of SR and is $(\frac{1}{2}c, \frac{1}{2}d - \frac{1}{2}m)$

The equation of the circle with centre K and radius OK is $x^2 - cx + y^2 - (d - m)y = O$

This circle cuts the line (AB) $x - c = O$ at the points indicated by the solution of the equation $y^2 - (d - m)y = O$, i.e when $y = O$ and when $y = (d - m)$

But $y = O$ at Q, where AR meets BC, and $y = (d - m)$ at P, which is midway between A and R, hence OP is a diameter of this circle

The radius of the circle, centre S, is $\sqrt{m^2 + a^2}$

The radius of the smaller circle, centre K, is $\frac{1}{2}\sqrt{c^2 + (d - m)^2}$, which is equal to $\frac{1}{2}\sqrt{m^2 + a^2}$

These results may now be transferred from the code of coordinate geometry to the code of ordinary plane geometry.

ABC is any triangle

S is the circum-centre

R, where the perpendiculars intersect, is the ortho-centre

The ortho centre is distant from any corner of the triangle by twice the length of the perpendicular from the circum-centre to the corresponding base of the triangle i e the two perpendiculars from the circum- and ortho centres which are parallel (i e SO and AQ)

The join of the circum and ortho- centres is a fixed line in the triangle (SR) In this join are two points (i) the point, G which is a third of the length of the join from the circum-centre, and (ii) the mid point of the join (K)

The first of these is the point of concurrency of the lines joining the corners of the triangle to the mid-points of the opposite sides i e G is the centroid, or C G

The second of these is the centre of a circle which passes through the three mid points of the sides of the triangle, the three feet of the perpendiculars through the ortho centre, and the three points mid-way between the ortho-centre and the corners of the triangle i e in all nine points, the circle is labelled the nine point circle, the N P circle, of the triangle ABC

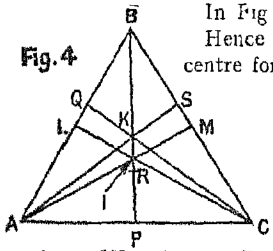
The radius of the circum-circle is double the radius of the N P circle (i e SA = SB = SC = OP)

OSAP and OSPR are parallelograms

Since the three feet of the perpendiculars determine the pedal triangle, it follows that the N P circle of ABC is the circum circle of the pedal triangle of ABC

It follows also that O is the in centre and A, and B, and C are the out centres of the pedal triangle

Fig. 4



In Fig 4 AB = BC, AQC = ASC = 90 Hence K is the ortho-centre I is the in-centre for AM, CL, and BP are bisectors of the angles R is the circum-centre, hence $RP = \frac{1}{2}b \cot B$, whence $KB = b \cot B$

IP = the in radius $= (s - b) \tan \frac{1}{2}B$

$BP = \frac{1}{2}b \cot \frac{1}{2}B$

whence $IK = \frac{1}{2}b \cot \frac{1}{2}B - b \cot B - (s - b) \tan \frac{1}{2}B$

$= \frac{1}{2}b \tan B - (s - b) \tan \frac{1}{2}B$

Drill. (1) In Fig. 1, given that ABC = 90 and BC = BA CD, find the ratio between EK and AM.

(2) In Fig 2, given that AM = MK and ACB = 60, find the length of DM in terms of AC.

Revision. If a man sells goods at 2s. 6d. each he makes a profit on selling price of 25 per cent Find a scale of rates of profit on cost for all prices at a penny difference between 2s. and 3s.

Expansion A rectangle is rotated round one of its long sides as a hinge Consider the results of the rotation on (i) the other long side, (ii) each of the two short sides Estimate in terms of the original rectangle the areas of rotation and the volume of the solid of revolution

Repeat the experiment with a right-angled triangle, using one of the shorter sides as a hinge

Solutions to Problems in Lesson 33.

Drill. (1) Speeds in hours per mile 1/25, 1/30. Difference in hours $\frac{1}{4}$. Speed in m.p.h. increases by 1/5, and in hours p.m. decreases by 1/6 of original speed 1/6 of 1/25 = 1/150

$(\frac{1}{4})/(1/150) = 37\frac{1}{2}$. Journey = $37\frac{1}{2}$ miles.

(2) Time difference = 12 min. per 60 miles = 1/300 hours p.m.

$$\frac{1}{50} - \frac{1}{x} = 1/300\text{; i.e. } x = 60$$

Time difference = 17 min. per 60 miles = 17/3600 h.p.m.

$$\frac{1}{50} - \frac{1}{y} = 17/3600\text{; i.e. } y = 65\tfrac{5}{11}.$$

Normal speed in m.p.h. $65\frac{5}{11}$; actual 60.

(3) a = 6 cos 30 = 5·2 ; B + C = 120° ; B = 105° ; C = 15° ; a/sin A = 10·4 ; b = 10·4 sin 105 = 10·5 ; c = 10·4 sin 15 = 2·7.

Revision. (1) (a) $58\frac{2}{3}$, (b) $3\frac{3}{8}$ sec. ; (c) 9 sec. ; (d) (i) $3\frac{3}{4}$ sec (ii) $3\frac{3}{11}$ sec ; (e) (i) $4\frac{1}{2}$ sec. ; (ii) $31\frac{1}{2}$ sec.

(2) B + C = 140° B − C = 10° ; B = 75° ; C = 65°
b + c = cot 20/tan $\frac{1}{2}$B − $\frac{1}{2}$C, b + c = 2·748/0·0875 = 31·4
b = 16·2 ; c = 15·2 . b/sin B = 15·6, a = 15·6 sin 40 = 10·2.

Expansion. (1.)

Pts. (3, ± 4) tangents 4y ± 3x = 25.

Pts. (± $2\sqrt{5}$, $\sqrt{5}$) tangents y ± 2x = $5\sqrt{5}$.

(2) Pts. (± $\sqrt{6}$, 12) tangents y + 24 = $6\sqrt{6}$x.

Pt. (± $\sqrt{2}$, O) tangent y + 12 = $6\sqrt{2}$x.

Our Course in Mathematics is continued in Volume 5.

LESSON 19

Napoleon's Rise to Greatness

(See plate 59)

During the French Revolution the influence of J. J. Rousseau undoubtedly strengthened the reaction against the complexities and artificiality of the old régime, and was directed towards the formation of new cults of simplicity, return to Nature and Deism. He cannot, however, be identified with the philosophers of the Encyclopedia who attracted the attention, first of the aristocracy and afterwards of the bourgeoisie, by focusing the social discontent of their day, because his was not, like theirs, a critical philosophy—it was an intuitive one. That France emerged from the Revolution with renewed vitality and excellent institutions is in great measure the work of the "philosopher" of the 18th century. Rousseau was the forerunner of the naturalism and romanticism of the 19th century—a herald of the reaction against the intellectual views of the Encyclopedists.

Apart from the financial difficulties, which were many, the problem of food supplies faced the men of the Republic in 1793 after the declaration of war with England when the coasts of all French territories were blockaded by the British navy. It is interesting to note that, as in Germany during the Great War under similar conditions, substitutes were devised for some of the prohibited goods, one of these led to the great French beet-sugar industry. The communes of the larger towns introduced a rationing system with food cards, later the State requisitioned food and sold it at low prices.

The Revolution failed to establish democracy in France. From the rise of the Committee of Public Safety (1793) already the government ceased to be democratic in form, and from the fall of Robespierre (1794) it ceased to be democratic in substance. The France which emerged, however, was a France in which the bourgeoisie was the predominant class. From the end of the Terror the tone of public life changed. The men of the Revolution—moderate Girondins, extremist Jacobins, the followers of Danton, of Robespierre and of other apostles of violence—had

wiped each other out. The consulate and the empire under Napoleon completed the destruction of democracy for a time, but restored order into the various departments of public life.

At the beginning of the war in 1793 the administration of the French armies was placed in the hands of Carnot, who devoted himself to that task with skill. The French Republic, which had taken over the government of an apparently bankrupt state, was able to defy the armies of all Europe and to defeat them repeatedly. Robespierre controlled the Committee of Public Safety, which sent out its agents empowered to act everywhere with arbitrary authority. Revolts in La Vendée and elsewhere were suppressed; Toulon, still Royalist, was besieged, and suspects were slaughtered with a horrible ferocity. In Paris for several weeks the guillotine had an average of fifty victims a day, while the supreme authority amounting to a dictatorship was practically exercised by Robespierre. He was carried to the pinnacle of power by his ruthless competence and the force of his fanaticism. Marat had proclaimed him "The Incorruptible." He became for a brief period the high priest of the new religion of the Revolution.

Toulon was captured from its Royalist defenders in December, 1793, in spite of the British fleet, mainly by the skill of Napoleon Bonaparte (*1769–1821*), a young artillery officer whose military skill had already won golden opinions from Carnot. Meanwhile, Robespierre had struck down first one group of his colleagues, the Hébertists, whose obscenities had gone beyond what he could endure, and then Danton, who had latterly been exerting his influence on the side of moderation. The Girondists, the party who might be called the Literary Republicans, had been struck down long before. But the Terror had reached an intolerable height. A combination was suddenly formed against Robespierre, who, with the two colleagues, Saint Just and Couthon, most closely associated with him, was in his turn struck down in July, 1794. Danton's threat on the day he was condemned had been no idle one. "Scoundrel! The scaffold will claim you. You next, Robespierre." The reaction had set in and the Terror was ended.

Establishment of the Directory. The government which replaced that of Robespierre produced its new Constitution according to the recognized form. A council of five, called the Directory, was to have the supreme administrative control,

supported by two legislative assemblies. The plan was violently opposed in Paris; when the time arrived for the election of the Assembly there was an insurrection in the capital. Barras, the head of the Five, and Carnot were prepared for the emergency, and had chosen as their agent for crushing the insurrection the young artilleryman who had taken Toulon. Bonaparte's cannon cleared the streets of Paris, and the Directory was established.

Bonaparte's marriage, early in 1796, with a fashionable widow, Josephine Beauharnais, who as the mistress of Barras had escaped the guillotine, strengthened his reactionary tendencies, awakening the patrician instincts inherited from his mother, Marie Letizia Ramolino, who came of an old Corsican military family. He had exchanged Jacobinism for a cynical opportunism, when in March of the same year he set out to take command of the French armies in Italy.

Of the circle of enemies who had not yet dropped off was the king of Sardinia, whose possessions of Savoy and Piedmont commanded the passage between France and northern Italy, which now, as always, was one of the battlefields with Austria. The object of Bonaparte's plan of campaign was to force Sardinia into neutrality, and to win the rest of north Italy from Austria. The campaign was conducted with an extraordinary brilliance and with a total disregard of the stereotyped rules of strategy.

By the swiftness of his movements, Bonaparte, with smaller forces, was able to surprise the central Austrian army at Montenotte, and shatter it so that the second Austrian army had to fall back to the eastward, while the king of Sardinia retired westwards. The latter, finding himself isolated, was in haste to make his peace. Bonaparte secured Milan by a brilliant victory at the bridge of Lodi. Naples, which was supposed to be in alliance with Austria, made its own peace instead of coming to Austria's help. New Austrian armies advanced from Tirol; Bonaparte shattered them at Arcola and Rivoli.

In 1797, acting on his own responsibility, he advanced out of Italy, and forced upon Austria the treaty of Campo Formio, with the cession of the Austrian Netherlands and Lombardy. On the pretext that an unfriendly Venice was a danger, he had occupied the city, blotted out the Venetian Republic (1797) and carried off the chief art treasures to grace the Louvre in Paris; the famous bronze horses he had removed from St. Mark's for placing on the Arc de Triomphe. The British were now isolated;

but earlier in the year the fleet under Admiral Jervis had won a decisive victory at Cape St. Vincent over the Spaniards, who, as well as Holland, now converted into the Batavian Republic, had allied themselves with the French. Immediately after the treaty of Campo Formio, the British fleet under Admiral Duncan destroyed the Dutch fleet in the battle of Camperdown.

Battle of the Nile. Bonaparte, though not yet thirty, had been made by his successes the most powerful man in France. Seeing no prospect of destroying the British navy, he formed the design of seizing upon Egypt as a basis for securing western Asia, and making that in its turn the base for striking at India on the one side and at Europe on the other The Directory were well enough pleased to get their too-powerful general out of their way in Paris for a time. Bonaparte's armament set out from Toulon, evading Nelson (1758–1805), who was in command of the Mediterranean fleet. The armament reached Egypt where Bonaparte set about his conquest. But Nelson, convinced that the fleet had made for Egypt, discovered its whereabouts, and came upon it in the bay of Aboukir, where he won the overwhelming naval victory usually called the battle of the Nile (1798) The French Mediterranean fleet had ceased to exist; Bonaparte in Egypt was completely cut off and isolated from his real base in France. Hence, although he mastered Egypt itself, he failed in the attack launched therefrom upon Syria, for he could not advance without securing the port of Acre, and Acre proved impregnable. It was in Egypt that Napoleon openly doffed his leanings towards Jacobinism. "Savage man is a dog," summed up his impressions and his revolt against Rousseau with his cult of the "Noble Savage" and the perfectibility of man

In 1799 Russia, where czar Paul had succeeded Catherine, joined Great Britain, and Austria again declared war upon France. The Bourbon monarchy was restored at Naples, and the Russian general Suwarrow was conducting a successful campaign in northern Italy, when Bonaparte at last learnt what was going on in the west, events of which no news had reached him in Egypt. The moment had come when he must assert himself, and take the government of France into his own hands. Leaving Egypt in command of a lieutenant, Kléber, he took boat with a few companions, and hurried to Paris, where he was hailed as the conqueror of Egypt.

LESSON 20

From First Consul to Emperor

(See plate 60)

By the end of 1800 Bonaparte had got rid of, to use modern terminology, the "red" leaders of the French revolution, under the pretext that they had concocted a plot which he knew to be "white," or royalist. If he could have adopted a peaceful policy abroad, his success would have been not only phenomenal but lasting. The czar Paul had changed his attitude since he had discovered in the First Consul the incarnation not of revolutionary France, but of absolutism. He was offended, not only with Austria, but also with the British, because the latter Power, having captured Malta, did not hand it over to him, as had been intended when Russia was still a member of the coalition. He sought to revive a combination of the Baltic Powers, known as the Armed Neutrality, directed against the rights of search claimed by British ships, rights which were of the utmost value to a predominant naval Power, but which were much resented by neutrals. It was clearly understood in England that his real intention was to place the fleets of Denmark, Sweden and Russia at the disposal of France, and so to isolate Great Britain, for whom the sea was the only possible field of warfare.

A British fleet suddenly appeared before Copenhagen, with Nelson second in command. The Danes were required to hand over their fleet to the British for protection. They refused, but were promptly forced to submission by the battle of the Baltic or Copenhagen (1801), won by Nelson, who declined to see his senior officer's signal when ordered to cease firing. The Danish fleet was carried off; the assassination of the czar raised to the throne Alexander I, who was completely antagonistic to his father's ideas, and desired British friendship. At the same time a British expedition destroyed the French domination in Egypt, and compelled the withdrawal of the French troops. The result was that the war was brought to a nominal conclusion by the Peace of Amiens, in March, 1802.

France under the First Consul. The First Consul had in effect, though not in name, transformed the republic into an absolute

monarchy. Not one of the whole series of constitutions which were intended theoretically to establish democracy had been capable of remaining in working order for any prolonged period. The old aristocratic régime of privilege had disappeared. The people at large had been relieved from their burdens, their real grievances and when that had been accomplished they cared little enough about actual participation in the government. They were ready to acquiesce in the new despotism. It was practicable for the great military chief to set about some reconciliation of the discordant elements in the state. The Republic had been hostile to the Church; Bonaparte regarded the Church as a useful instrument provided that it was held in due subordination to the state.

The court of the First Consul became as splendid as the old courts of the Bourbons. Under his direction an admirable administration devoted itself to the production of magnificent public works, which if costly were still of the utmost value in increasing the national prosperity. Especially notable was the care bestowed by Bonaparte upon the Code Napoleon, a great codification of the laws, accompanied by reforms which established a common system (when it was at last completed some years later) all over the country displacing the interminable confusion of the peculiar local laws and usages which had prevailed for centuries. The application of the code in the German territories which fell under the sway of Napoleon's empire extended its influence far beyond the borders of France.

But Napoleon, who began to use his first name alone, after the manner of royalties, while he was still nominally only the First Consul of the Republic, engaged himself not only upon domestic administration during this period of peace. He was, in fact, reorganizing Germany in his own interests. Theoretically, Germany was reorganizing itself, a diet having been established to that end. But, practically, it was controlled in the interests of France and Russia, and incidentally of Prussia, because the two great Powers on the east and west intended Prussia to counterbalance Austria. In fact, the process meant the actual absorption by France or Prussia of German territories, whose princes were compensated by the transfer of ecclesiastical territories.

The militant republic acting as liberator had set up the Batavian republic, the Swiss republic, and sundry republics

in north Italy. It soon became evident that each of these republics was to be made a dependency of France. Europe might be alarmed, but it was paralysed for action.

The one power which was not paralysed was Britain. In spite of the Peace of Amiens, neither France nor Britain was in any haste to carry out the terms agreed upon. Each suspected the other of intending to wait only till its rival's evacuations were completed to declare its own purpose of not carrying out its own evacuations at all. The truce at best was only a hollow one. As the months passed the relations became more and more strained, distrust and suspicion increased on both sides of the Channel, and in the summer of 1803 war was again declared between the two powers.

Napoleon was now determined to accomplish the invasion of England, for he was assured that his armies on British soil would be victorious. But he found himself face to face with a small barrier—a little stretch of water—which proved insuperable. While British fleets held the command of the Channel, a French army could not be landed. He massed his troops at Boulogne, waited for an opportunity, and tried to create one.

The British, on the other side of the Channel, made up great regiments of volunteers, for the most part of a very amateur description. Pitt's government and the naval authorities were perfectly confident that the opportunity never would come for an effective landing. Nevertheless, a black terror hung over all England for a space of more than two years. All the fighting was in the nature of privateering raids upon commerce, because the French ports were watched, and no French squadron could put to sea without imminent risk of total destruction; and, on the other hand, Britain had no army with which to attempt an invasion of French territory.

Napoleon as Emperor. It was now that Napoleon shocked Europe and terrorized the French royalists by kidnapping on German soil and then shooting, the Duc d'Enghien, a prince of the French blood royal, in consequence of a royalist plot. This crime was in one sense a blunder, as it not only outraged the collective conscience of Europe, but made an active enemy of the young czar Alexander. In another sense it succeeded, for it placated the remnant of Jacobins, who now supported Napoleon's assumption of the imperial title. This he took, crowning himself Emperor in Notre Dame on December 2, 1804.

He hoped to gain European recognition and security against Bourbon conspiracies. But the czar Alexander joined with Pitt in efforts to build up a new coalition against him. In the summer of 1805 the coalition was joined by the Austrian emperor though Prussia still held aloof Russia and Austria now set about preparing their armies for a renewal of the war

Scheme to Invade England. Napoleon meant to strike his decisive blow at Britain before the general conflagration should break out His plan was to divide the British fleet by enticing Nelson to the West Indies. Villeneuve, with the decoying fleet, was to evade his pursuer, return to Europe, release the fleet blockaded in Brest, crush the Channel fleet, and so clear the way for the army at Boulogne to be hurled upon the shores of Britain. As a matter of fact, the British fleet was quite prepared to give a satisfactory account of the French fleet even in the absence of Nelson and his squadron Villeneuve did decoy Nelson away, and did return with Nelson in chase, but he did not relieve Brest. He found a squadron waiting for him, saw that the plan was hopeless, and retreated to Cadiz. A few weeks later Nelson had rejoined the Mediterranean squadron the combined French and Spanish fleets put to sea, and were caught and annihilated by Nelson at the decisive battle of Trafalgar (October 21, 1805). Trafalgar set the seal on the British naval supremacy, but Nelson died in the battle

Villeneuve's retreat to Cadiz had been enough to prove to Napoleon the futility of his scheme of invasion. Without a moment's hesitation he resolved to strike at once against the coalition on the Continent. The army of invasion was hurled across Europe, and swooped upon the main Austrian army, which was gathering at Ulm The day before Trafalgar was fought, the Austrians were forced to capitulate. In three weeks the French were in Vienna The Russians were coming up, and a second Austrian force was moving to join them. On December 2, at Austerlitz, Napoleon fell upon the Russians, and won a complete and decisive victory. The king of Prussia, who had been thinking of joining the coalition, changed his mind. The Russians retired in disgust, and Napoleon dictated his terms to Austria in the Treaty of Pressburg.

LESSON 21

Napoleon at His Zenith

(See plate 61)

Before the victory of Austerlitz (1805), Napoleon, with an unfriendly Prussia on his flank, was in a somewhat difficult situation; after it he gave the law to the Continent. Previously the north Italian republics had invited him to accept the crown of the kingdom of Italy; the remaining Austrian provinces in Italy were now annexed to that kingdom. Outlying Austrian provinces in Germany were transferred to German princes who had supported Napoleon. Prussia was momentarily placated with the promise of Hanover. A number of German principalities were combined in the Confederation of the Rhine, and thus prepared for the formation of a large Napoleonic-German union. The emperor presented three of his brothers with kingdoms That of Westphalia, composed of some German principalities, was bestowed upon Jerome in 1807. Holland and Belgium were handed to Louis, and Joseph was planted at Naples, whence the ejected Bourbon monarch betook himself to the island of Sicily, which was at that time virtually under British control.

Prussia, under Frederick William III, had long pursued a wavering policy, which in the spring of 1806 had sunk into inertia. Napoleon, however, pressed the Prussians too hard; their old martial spirit flared up, and war ensued, only to result in disastrous defeats at Jena and Auerstädt (Oct. 14, 1806). Napoleon occupied Berlin, and the Prussian king fled to Memel, on the Niemen. Czar Alexander came to his aid; the joint Russian and German forces advanced but were defeated at Friedland in June, 1807. The czar then deserted Prussia, met Napoleon at a secret conference, and the two potentates arranged the terms of the Treaty of Tilsit, by which they agreed to make common cause against any power which did not accept the mediation of one of them. Prussia was penalized by the loss of Polish territories, which, in the form of the grand duchy of Warsaw, were handed over to Saxony, Napoleon's constant ally.

In England, public opinion did not take any extended view.

To the English, as English, it mattered little that the Austrians and Prussians were crushed by the French, but they quite understood that after Trafalgar there was no fear of a French army coming into England.

But while in England people were content to take their own insular and complacent view of the position on the Continent, Trafalgar seemed a very small thing in comparison with Austerlitz or Jena. Napoleon was probably the one man who, without in the least undervaluing his own victories, could understand that Trafalgar was, for the time at least, the destruction of his hopes and schemes so far as England was concerned. He knew there was no longer a possibility of his obtaining command of the Channel for the few hours or days that he required, and saw that other means must be found for breaking the power of England.

Napoleon, after Tilsit, was master of western Europe, but farther off than ever from destroying British power. As he could do nothing against British fleets, he framed a design for ruining British commerce, the source of wealth and, therefore, of power. This scheme, called the Continental System, he formulated in the decrees issued from Berlin and Milan in 1806 and 1807. No British goods or goods borne in British ships were to be admitted to any port under French control or in the hands of any government in dependence on the French Empire. The weak points of the scheme were, first, that the nations of Europe required more imperatively to buy British goods than the British required to sell them, and in the second place, that the exclusion could only be partial so long as there were ports on the Continent not under French control which persisted in admitting British goods.

Great Britain replied by the Orders in Council which declared that all ports closed to British goods were in a state of blockade, and were consequently not open to any neutral commerce whatever. A very lucrative, if dangerous, business was developed for the smuggling of British goods into the Continent, and the French government itself was actually obliged to grant licences enabling the holders to import goods which were absolutely necessary. On the other hand, the Continental System was a blunder—the fundamental cause of Napoleon's ruin. The pressure it imposed on Europe was the most potent cause of the revolt against the Napoleonic domination.

If British commerce was being checked, Continental commerce was being throttled Napoleon, in his visions of world domination, entirely left out of count the sense of nationalism He thought of geographical areas, and perhaps of dynasties but not of peoples, and he was presently to learn that, though he might impose obedience upon governments, the spirit of nationalism, when once aroused could not be stamped out

His first teachers were in the Iberian peninsula Portugal had stood aside from all the European complications, Napoleon ordered the Portuguese government to join the Continental System, it refused French troops entered Portugal which appealed to Britain At the same time Napoleon chose to enforce the abdication of the Spanish king and his son both of whom were incompetent and to bring over his own brother Joseph to occupy the throne of Spain while his Neapolitan kingdom was transferred to Marshal Murat

The Spanish people however, entirely refused to accept a king at Napoleon s dictation, and broke out into a fury of insurrection French troops swept over Spain and, as a matter of course, were too strong for such Spanish armies as could be raised to beat them in the open field Nevertheless, a French force was trapped and compelled to capitulate at Baylen and everywhere bands of insurgents cut off the supplies and played havoc on their lines of communication

The Peninsular War. The British government resolved now to assist Portugal, and to support the Spanish national party, with whom George III and his Parliament formed a treaty of alliance A British force under Sir Arthur Wellesley landed, defeated the French commander, and compelled the French to evacuate Portugal But Wellesley s senior officers, who arrived on the scene at the moment of victory, conceded terms which were found unsatisfactory to England All the generals were recalled for inquiry The command in the Peninsula was given to Sir John Moore Napoleon personally commanded the forces engaged in crushing the Spanish resistance in the south, when Moore effected a brilliant diversion by marching upon his lines of communication The emperor, foreseeing a troublesome and somewhat inglorious operation before him, and having other objects in his mind besides the quelling of the Spaniards, left the business to Marshal Soult Moore drew the pursuing army to Corunna (1809), where Soult's attack was decisively

repulsed, and, though Moore himself fell in action, his troops were enabled to embark.

With the return of Wellesley (soon to be known as Wellington) in the spring, opens the real story of the Peninsular War, when Britain took the rôle of a military as well as a naval power for the first time since the days of Marlborough. For four years a quarter of a million of French troops were locked up in the Peninsula, vainly endeavouring to suppress the Spanish guerrillas and the army of the British general who, after every blow which he was able to strike, was obliged to fall back again on the defensive into Portugal. Napoleon never returned to the Peninsula, being fully engaged in gaining a succession of victories which drove the Austrians to the north bank of the Danube, opposite Vienna. He entrusted the work in Spain to one after another of his most brilliant marshals, always believing that the British would be swept into the sea and the Spaniards crushed into submission.

In 1809 Wellington won his title of viscount by the victory of Talavera (he was made duke of Wellington in 1814). He was obliged, however, owing to the insufficiency of his forces, to fall back into Portugal where for the next year he was organizing an impregnable position covering Lisbon behind the lines of Torres Vedras. In 1810 Napoleon dispatched Masséna against him. Wellington checked him at Busaco, but was forced to retreat to Torres Vedras. All through the winter Masséna vainly endeavoured to find an entry into the lines. In the spring of 1811 he was obliged to retreat, and was finally beaten at Fuentes d'Oñoro. Marmont took the place of Masséna. It was not till the beginning of 1812 that Wellington captured the two frontier fortresses of Ciudad Rodrigo and Badajos. In July Marmont was completely routed at Salamanca ; but even then, though Wellington marched to Madrid, he had to fall back once more into Portugal.

In 1810 Napoleon married Marie Louise, daughter of Francis I of Austria. The recent divorce from Josephine had been prompted by political motives. Napoleon desired an heir. The son born to him and Marie Louise in 1811 was proclaimed

LESSON 22

From Moscow to St. Helena

(See plate 61)

When Napoleon had left his marshals to complete the subjugation of Spain and Portugal and drive out the intruding English, the war in the Peninsula had seemed to him a side issue, and of its conclusion he entertained no doubt. In 1809 he had taken Tirol from Austria and presented it to his ally Bavaria; both Austrians and Tirolese had resisted this disposal, at first with some success, only to be finally defeated at Wagram (July 6, 1809). Thereafter Austria had made peace, ceding at the Treaty of Vienna portions of the empire, and Napoleon had sought to consolidate his European position by marriage with the archduchess Marie Louise, daughter of the emperor Francis I of Austria. Rome having also been annexed to the French empire, the son born in 1811 was proclaimed king of Rome.

The years of Napoleon's supremacy (1809-12) were marked by great public works, which brought new life not only into France, but into central Europe. The Code Napoléon had beneficent results in Italy, Switzerland, the Confederation of the Rhine and the Grand Duchy of Warsaw. Education was improved, and religious toleration extended. In Italy, as in Germany, he struck at the abuses of the old régime, sweeping away petty states and unifying the people in larger territories, within which were free trade, equality of law, educational schemes and the semblance of a popular government.

His experiment of a "United States of Europe" required, however, years of peace for its materialization, and peace was still far from Napoleon's plans—far also from the minds of the king and czar he had humiliated. Prussia, though he did not know it, was being secretly reorganized, and the Prussian minister Stein, who had begun the reorganization, was in the czar's service. At the end of 1811 the latter broke away from the Continental System, making it clear that Russia, dependent as it was on colonial goods, could no longer endure this harsh fiscal policy.

Napoleon in Russia. Russia's defection meant wreck to the whole scheme; hence in 1812 Napoleon resolved to compel submission, collected the mightiest army—half a million men—that had yet been raised, and began the war in June on the Niemen—a war which ended in the most tremendous disaster yet experienced.

Great Russian armies took the field, but he could not bring them to a decisive action. They retreated before him continually, fighting only rearguard actions and stripping the country of supplies, till they turned at bay at Borodino, where Napoleon gained a victory at enormous cost. Again they retired; a week later he was in Moscow, and that same night Moscow itself was in flames. The Russians had fired the city without attempting to hold it. For a month the depleted Grand Army abode in a town that had been gutted, with no supplies obtainable. Then, on October 19, it set out on the return march across a country already laid bare, with the Russians hovering on its flank cutting off supplies and stragglers. A particularly cruel winter descended on the now starving and exhausted troops.

As they were crossing the icy Beresina, the Russian general Tchichagoff came up with 27,000 men and fell on Marshal Ney and the "Sacred Squadron." These auxiliary Russian forces had been released, because Stratford Canning, aged twenty-three, left as secretary in Constantinople in charge of the British Mission, without a chief and without instructions, without military or naval forces to back him, had, after two years' personal exertions, concluded the Peace of Bucharest in 1812, between Russia and Turkey, thus setting free the Russian troops under Tchichagoff.

It was a mere remnant that finally struggled back over the Niemen into Prussian territory under Ney's command in December. Napoleon had hastened ahead to try to save the situation in the west, but from this disastrous retreat his fortunes never recovered.

Prussia and Austria were both Napoleon's allies, but neither was disposed to offer him aid. Prussia was an ally only because since Jena and Tilsit she had no choice. In February, 1813, she became Russia's declared ally. Metternich, the astute statesman who now ruled Austria, held aloof, waiting to snatch Austria's advantage as the new situation revealed itself. In Paris Napoleon was organizing incredible new armies, calling in troops from Spain, cowing the west Germans. In May and June he was

able to defeat the Prussians heavily at Lützen. Austria's help he did not obtain, because Metternich, hearing of Wellington's victory at the decisive battle of Vittoria, and that the depleted French armies were in full retreat from the Peninsula, saw that Napoleon's position was really critical and that his demands were extreme and impracticable. In stormy interviews the statesman and emperor failed to come to any agreement, and Metternich at length decided to join the Allies It has been said that no one single act of Napoleon's was so disastrous as this refusal of Metternich's reasonable terms.

Battle of the Nations. The first attempt of the Allies failed. Napoleon won his last great victory at Dresden (August 23, 1813); but elsewhere things went badly for him, his lieutenants suffering serious reverses at the hands of the Allies. Then at Leipzig, October 16–19, was fought the "Battle of the Nations," which ended in Napoleon's defeat and retreat over the Rhine. He still refused the offered terms, which would have left the Rhine, the Pyrenees and the Alps as the boundaries of France. Through the first three months of 1814 he fought on, on French soil, defeating the on-rolling armies of the Allies in detail (while Soult and Wellington were fighting in the south), but unable to stay the advancing tide, till he was forced by his own marshals and ministers to submit when Paris itself capitulated on March 31. On April 6 he abdicated.

The Allies bestowed on him the principality of Elba—a small island whither he was exiled, between Corsica and the Italian coast—made a preliminary settlement of European boundaries, restored the exiled Louis XVIII to the throne of France, and arranged for a great congress to be held at Vienna for permanent settlement in the autumn.

The five Great Powers, Austria, Russia, Prussia, Great Britain and monarchical France, were to act together for the restoration of universal peace. But when they met at Vienna the points of disagreement seemed likely to set them quarrelling instead, till the startling news arrived that the exile had slipped back from Elba, that he had landed in France on March 1, that he was being hailed with acclamation, that he was on his way to Paris, and that his old veterans were flocking to his standard. King Louis took hasty flight from his capital, and Napoleon was proclaimed emperor once again.

The discords of the Powers were hushed in face of the peril.

Napoleon might make the most pacific declarations, but no Power in Europe dared to trust him. Whatever else happened, Napoleon must go. He had no intention of going, and he had the enormous advantage that his affairs were under the direction of a single brain and a single will, whereas those of the Allies were controlled by half a dozen different brains and wills. He resolved to strike at once, and destroy his enemies separately before they had time to unite their forces for his destruction.

Waterloo. The armies of Austria and Russia were far away In Belgium there was a heterogeneous collection of regiments, British and Germans, Dutch and Belgians, with the duke of Wellington in command; near at hand the Prussian forces were assembled under Blücher, when, some three months after his first reappearance in Paris, Napoleon was across the frontier. His object was to strike between Blücher and Wellington before they could effect a junction, and to shatter first one and then the other. He almost succeeded. At Ligny he defeated Blücher and drove him to retreat. Then he turned upon Wellington, who took up his station at Waterloo, covering Brussels. Blücher, however, aware of the vital importance of effecting his junction with Wellington, had not fallen back to his own base at Namur, as Napoleon supposed, but had wheeled northwards upon Wavre, thereby eluding the force which had been detached to hold him in check while Wellington was being annihilated.

On June 18, 1815, Napoleon and Wellington were facing one another. From a little before midday till late in the afternoon a stubborn battle raged, Wellington obstinately holding the slopes against the furious attacks of the French. But as the afternoon advanced Blücher's troops were coming up from Wavre. Their arrival on the scene of conflict was decisive. As they crashed in upon the French right, the thin red line of the British hurled back the last desperate onslaught of Napoleon's Old Guard and swept forward. The French broke, the defeat became a rout, and the rout a *sauve qui peut*, with the Prussians in pursuit. Napoleon's cause was hopelessly lost. A few days later he surrendered himself to the commander of a British warship Napoleon, by the agreement of the Powers, was sent to spend the remainder of his days on the lonely rock of St. Helena, far away in the South Atlantic. He died May 5, 1821.

Our Course in Modern History is continued in Volume 5.

LESSON 16

Kant's Solution of the Moral Question

THE preceding lesson contained a brief account of a psychological doctrine, the doctrine of self-determinism, the corollary of which was Man s servitude to his desires and impulses Man, in this view is determined not by external forces but by his own temperament We can say of any individual, he did so and so because he was that sort of person " Exhibit a man s actions—as psycho-analysis succeeds in doing—is proceeding always from the reaction of his character to a given situation represent his character at any given moment as the determined result of his past actions and the chain of causality is complete So far as ethics is concerned, *tout comprendre c est tout pardonner* is the only maxim

Kant admits the conclusions of this analysis, so far as they apply to Man from the point of view of anthropology " So far, he says as men act according to inclination, do things because they like doing them, or avoid them because they dislike them their actions are what he calls heteronomous," governed by laws over which they have no control We often assume, when we are trying to explain human actions, that they are the result of the interaction of character and environment, and are not, therefore, to be praised or blamed, but *understood* But, in addition to these various likes and dislikes, preferences and prejudices which can be shown to have been determined for us there is a further judgement which we make—a moral judgement—which tells us not what we want to do, but what we ought to do The interesting thing about this judgement is its unqualified character Its commands are absolute In the first place, it does not make its injunctions dependent upon the achievement of any end It does not say, ' if you want to be happy and win the good opinion of your neighbour, or to go to Heaven, then you ought to behave in such and such a way " It says simply, " you ought to behave in such and such a way " Secondly, it is absolute because the obligation which it enjoins is not in the least affected by the strength of our desire to act otherwise than in accordance with it.

It does not say, "you ought to do x, if your temptation to do y is not too great": it says, "you ought to do x, whatever your temptation to do anything else." And in saying that you ought to do x, it implies also that you are free to do it. Thus the claim of morality cuts right across the pull of inclination and desire. Considered purely from the point of view of psychology and anthropology, Man is not free; in the moral sphere we act and judge as if we are free.

Now the ground for this claim that we should act from the dictates of duty, irrespective of our likes and dislikes, cannot be found in the phenomenal world, which, as we have seen, yields only a basis for determinism. Therefore, it must be looked for elsewhere. Kant's conclusion is that the moral self belongs to and derives from a world other than the phenomenal world, namely the *noumenal* world of real things, described in Lesson 14, (Volume 3, page 563.) For this reason its claims are absolute and take no account of likes and dislikes, circumstances and temptations, which are, of course, on Kant's view, all phenomenal.

Kant's Moral Imperative. Kant called the obligation to act morally "The Categorical Imperative," because of this absolute command which it makes. To say that it is absolute does not mean that we shall necessarily obey it. We may act usually, even always, as non-moral phenomenal beings. Nevertheless, the claim is there, whether we like to recognize it or not, and it is called absolute because it is completely unaffected by circumstances. Kant, in fact, supplemented his doctrine of the moral will with a number of subsidiary considerations.

For example, he pointed out that right action demands neither explanation, justification, nor incentive. If a person acts wrongly, there is always some special motive which makes him do so. He lies *because* he wishes to convince so and so, steals *in order to* become possessed of so and so. No incentive is, however, required for truth-telling or honest dealing. In so far as we tell the truth or act honestly—assuming that we ever do these things—we do them for their own sake.

Kant derived a number of subsidiary rules from his moral imperative. A famous one is the rule to "act only according to that maxim which you can at the same time will to be a universal law." If, that is to say, an action is such that everybody could perform the same action without conflict or self-contradiction, then it will be right. If we permit ourselves a freedom

of action which could not be extended universally, then we may be sure that we are going wrong.

An important difficulty may be pointed out. Kant suggests that when we are acting from desire our action is determined. It is only when we act morally that we are free. This suggests that whenever we act from desire—that is, whenever we do what we want to do—we are not acting morally, from which it seems to follow that we can always detect moral action from the circumstance that it is disagreeable. It may, no doubt, be true in practice that right action may generally be defined as the sort of action we dislike doing; but it is certainly not always so, and a theory which suggests that only those actions have moral value which go contrary to inclination is liable to form the basis of an unpleasant and only too familiar kind of Puritanism, one which is never at a loss to prove that we are doing our duty whenever we happen to want an excuse for making ourselves unpleasant.

Reading. Kant's philosophy is very difficult, and it is inadvisable for the student to tackle it in the raw. The most useful small books on Kant are: Adamson's "The Philosophy of Kant" (Blackwood) and A. D. Lindsay's "The Philosophy of Kant" (The People's Library).

LESSON 17

Introduction to Hegel's Philosophy

HEGEL's philosophy, like that of Kant, is exceedingly difficult, and the student is recommended not to study it intensively until he has a fairly general acquaintance with philosophical arguments and terms. In particular, a reading of Hegel demands a knowledge of Kant's philosophy, from the conclusions of which his own thought in almost every case arises. Hegel is by far the most philosophical of philosophers, just as Bach is the most musical of musicians and Spenser the most poetical of poets. This does not mean necessarily that he is the best of philosophers, but merely that his work exhibits in the highest degree the peculiar characteristics of philosophical reasoning, and, perhaps for that reason, has a special appeal for professional philosophers. During the last half of the nineteenth

century his influence was all-pervasive in Germany He influenced in different degrees all the subsequent German philosophers—even Schopenhauer's work, although its author revolted from Hegel's influence, is, nevertheless, permeated by Hegel's ideas—and it was currently thought at the time of the Great War that Hegel's theory of the State played a not inconsiderable part in the militant policy of Germany, which some considered to have been one of the main causes of the war

Hegel's influence was by no means confined to Germany As on the Continent, so in England, his philosophy was dominant throughout the latter part of the 19th and the first few years of the 20th century His English followers—F H Bradley, Bernard Bosanquet and T H Green—were the leading philosophers of the time, and it is only in the last twenty years that philosophy as a whole has emancipated itself from the doctrines of Hegel, from which there has been a widespread reaction Students who wish to read Hegel are recommended to procure a book entitled "Hegel's Logic of World and Idea," which is a translation of the second and third parts of what is known as the "Subjective Logic" The book has a valuable introduction by the translator, H S Macran, on the general characteristics of Hegel's thought F H Bradley's famous book "Appearance and Reality" is the most impressive statement in English of the Hegelian view of the world It is also a very eloquent book, passages from which are accustomed to appear in anthologies of English prose, and students who wish to understand the sort of world view for which Hegelianism is responsible, rather than to study the detailed structure of Hegel's philosophy, would be well advised to read "Appearance and Reality"

Hegel's Monism. Hegel maintains Kant's distinction between the world of appearance and that of reality, but he conceives the world of reality differently For him it is not a number of unknown entities (Kant's *noumena*), but a single, unified structure of thought If a palaeontologist discovers the thigh bone of an extinct creature—a mammoth, let us say—he is enabled to construct an outline sketch of the whole of the creature from the one bone This is because the bone has a coherent relation to the whole of the creature's structure It possesses, as it were, hooks which fit into the eyes of the other bones, and eyes or sockets which receive the hooks of its neighbours Thus, in virtue of its own characteristics, it determines and, as it were,

points forward to the characteristics of the other bones Hegel conceived each fragment of the universe, whether thought or thing, on the model of the isolated bone It had, he thought, hooks which grappled it on to the next fragment of reality, that was again linked to the next, so that the whole formed one coherent, unified structure Reflecting sufficiently on any one part or aspect of reality, one is led by logical and inevitable stages to the whole, which is a unified structure of thought

This structure of thought, besides constituting the world of reality, contains within itself the world of appearance also, which is to be regarded as a partially revealed aspect of it Thus Hegel's philosophy is an extreme statement of the view known as Monism, because it affirms reality to be fundamentally *one* unified whole, the appearance of many different things being regarded as delusive Since the unified whole with which reality is identified is also a structure of thought, Hegel's philosophy may be called Monistic Idealism

Axiom of Internal Relations. Hegel's conclusions follow from two different lines of argument, which deal respectively with the nature of things and with the nature of our thinking about things The argument about the nature of things is sometimes called the axiom of internal relations, and is as follows

If we seek to obtain a complete understanding of any one thing, we find that the endeavour involves a necessary reference to other things This is because, taken by itself, a thing is not self-sufficient Thus an egg is more oval than a ball, more brittle than leather, shinier than rock, and, if kept too long, it will smell Now all these facts about the egg involve the relations of the egg to some other object or set of objects, and the egg must have these relations in order that it may be the thing it is Therefore, the relations of the egg to other objects determine, at least in part, its nature, and partially constitute this nature They are not, strictly, like hooks attached to the egg from outside, linking it to other things, they penetrate into its very being, making it what it is But the relations also have other ends or terminals, namely, in the things to which the egg is related Of these things, too, they will, by the same argument, form part of the nature or being But, if the relations are part both of the egg and of the objects to which the egg is related, the egg and these objects are not really distinct and separate, but form part of the same related structure. Therefore, the apparent differences

between things are illusory, taken in isolation, things are not understandable, because they are not self-sufficient, that is, they are not real.

Theory of Knowledge. Hegel's theory of knowledge—how, that is to say, we know the external world—is a special case of the doctrine of internal relations. The difficulties in regard to theory of knowledge which had been raised by Hegel's predecessors were, he held, due to the fact that the problem had been wrongly formulated. Philosophers had thought of the knowing mind and of the object known as two different things, and of *knowledge as a relation which somehow brought them into contact*. Conceiving them as initially separate, they had never satisfactorily been able to bring them together. Hegel insisted that knowledge was, initially, a unity containing two aspects—the knowing mind and the object known. Take as an instance the knowledge of the pen with which one is writing. Hegel said, in effect, "You don't start with a mind or with the pen which the mind knows. You start with an act of knowledge—knowledge of pen." Knowledge of pen is a unity within which, by a subsequent act of reflection, we distinguish the two sides or aspects—"knowing mind" and "pen known." But the unity comes first. It is, so to speak, what is given. The distinction into elements or aspects is secondary and is made by mind for practical purposes. Thus both a mind and a pen are mental abstractions from a prior unity which contains them both. They do not exist in reality as separate isolated things.

LESSON 18

Hegel's Dialectic and Absolute

The last Lesson contained a general sketch of Hegel's philosophy, and concluded with a summary of the Axiom of Internal Relations, which seeks to show that things which appear to be separate and distinct are not so in reality. A second chain of argument seeks to show that any particular theory or point of view, if pressed to its logical conclusion, leads the mind into contradiction. The student of philosophy is always being confronted with arguments each of which

seems irrefutable, but all of which cannot be true, since some of them, at least contradict others For example, there are arguments to show that change or motion is unreal, instances of which were given in Lesson 5 (Volume 1, page 572) There are other arguments to show that change, and only change can be real Some of these are considered in a later Lesson in connexion with Bergson s philosophy Both sets of arguments appear to be irrefutable, but they cannot both be true Again, as we have seen, when considering Berkeley, a thing can be shown to be the sum of its qualities we can find no substance behind these qualities Yet, if the world were composed of qualities and only of qualities, we should be quite unable to account for the existence of things Again, there are valid reasons for believing in free will, reasons equally valid for believing in determinism

Both theories cannot be true, but each undoubtedly seems to contain some truth If, then they could be assimilated in a wider theory, which embraced both the contradictory opposites that wider theory would contain more truth than either taken in isolation Thus, in its search for truth, the mind is driven forward to a wider view that underlies both the previous contradictory views This wider view will be confronted with its opposite, and the mind will be driven to formulate something still more embracing This process, known as the dialectical process, proceeds indefinitely, until we reach the complete view of everything, or the whole truth about everything that is To this there will be no contradictory Moreover since it is related to the whole about which it is the truth, it will, by the Axiom of Internal Relations, be continuous with and part of it The whole will, therefore be mental it will be a structure of thought

Contradictions of Time and Space. Hegel's philosophy travels many different roads, but all come to the same conclusion He is continually pointing out the contradictions in the conceptions which the unreflecting mind takes of the outside world Take, for instance, the concepts of time and space As a fairly simple example, we will proceed to show that no period of time can elapse Suppose, let us say, that we take the period of half an hour, now half that period must elapse before the whole of it This leaves us with a quarter of an hour

Half this quarter of an hour must elapse before the whole of it This leaves us with seven and a half minutes Half of the seven

and a half minutes must elapse before the whole of it. In this way we continue to shorten indefinitely the period of time which has to elapse; but, however short the period remaining, it will still be true that half of it must elapse before the whole of it. Something must always happen, therefore, before any period of time can elapse; before this something happens, something else must first happen, and so on *ad infinitum*. Therefore, no period of time can ever elapse.

Space, like time, is infinitely divisible, since however small a piece of space you take, it can always be halved. Space, therefore, consists of infinitely small pieces of space. But to add any number of infinitely small things together, none of which occupies any space, is not to produce space. The conclusion seems to be that time and space will not bear thinking about, because to think about them is to land oneself into hopeless contradictions

The solution which the Hegelian philosophy offers to these difficulties is to say that they arise because the concepts they involve, e.g. time, space, matter, are only partial, and have been abstracted by the mind from the whole to which they belong and in which alone they have meaning. Take a heart or a lung from a body or a note out of a symphony, and the heart, the lung and the note are, literally, different entities from what they were in the wholes to which they respectively belonged. Let us assume that they were only found in these wholes and never found outside them; then to consider them as they would be in isolation—that is, outside the wholes in which alone they have being—would be to falsify them.

In just the same way, Hegel holds in considering concepts such as time, space and matter divorced from the whole of reality, we are considering them as they, in fact, are not, and, therefore, inevitably land ourselves in difficulties and contradictions. Restore them to their places as aspects of the all-embracing whole, to which they belong and in which they are found, and the contradictions disappear.

The Absolute. Thus the process of philosophic reasoning leads us forward to a fundamental, all-embracing thought-structure, within which all differences between things are overcome and all contradictions between theories reconciled. This fundamental reality is Hegel's Absolute. All views of the universe other than that taken by the Absolute of itself, being partial, i.e. not the whole truth, are infected with error. It is

for this reason that they represent the universe as a collection of different things, and not as a unified structure of thought. The differences are, however, on a deeper analysis, shown to be unreal. Hegel's Absolute is a timeless structure of thought; it is all reality and the only reality. Everything which is, everything which can be thought, consists of different manifestations of the Absolute, which is, nevertheless, wholly present in each of its manifestations.

The following books are recommended for reading in connexion with this Lesson; "Hegel," by Edward Caird; "The Logic of Hegel," by William Wallace; "Appearance and Reality," by F. H. Bradley. The last should be attempted only when the student has already gained some considerable acquaintance with philosophical thought and methods of expression.

LESSON 19

Pragmatic Theory of Truth

MOST philosophy since Hegel consists of a succession of reactions from the idealistic monism which has been briefly described. The wholesale reaction of the 20th century from the ways of thought of the 19th has not left philosophy unaffected, with the result that the early years of the century witnessed the rise of a number of different philosophies each of which began by contesting the conclusions of Kant and Hegel. In the first place, the philosophy of pragmatism—a method of thought rather than a system of conclusions—threw doubt on the possibility of absolute truth and absolute knowledge, emphasized the efficacy of human will, and suggested that in knowing we make a universe to suit our purposes. Secondly, the philosophy of Bergson criticized the static implications of Hegel's Absolute, the notion, that is to say, that time is unreal and reality changeless, and developed a philosophy from the opposite premise that, literally, the only real thing in the universe is change. Thirdly, and most important of the three, the philosophy known as realism criticizes the idealist notion that things which are known depend for their existence on the knowing mind, and asserts that knowledge plays no part in the creations of its objects.

JOSEPHINE AND NAPOLEON. Josephine Beauharnais (1763-1814) married Napoleon in 1796, became empress in 1804 and was divorced in 1810.

Wallace Collection; Louvre

THE DOWNFALL OF ROBESPIERRE. Maximilien Robespierre (1758-94) had a seat among the Third Estate in the States General of 1789. Inspired by the most fanatical zeal, he became a leader of the extremist section known as the Mountain. He was the person most responsible for the Reign of Terror, and after the execution of Danton was in effect dictator. On the night of July 27 he was arrested in the Convention. A bullet fired by a gendarme (as may be seen from this contemporary illustration by Tassaert after Harriet) broke his jaw, but it was by the guillotine that he died the following day. MODERN HISTORY 19

British Museum

CROWNING OF NAPOLEON. This portion of a painting by J. L. David, court painter under the First Empire, shows what was perhaps the proudest moment in Napoleon's career, when, in Notre Dame, on December 2, 1804, with Josephine kneeling at his feet and his mother, "Madame Mere," smiling approval, he waved aside Pope Pius VII and crowned himself with the imperial crown. MODERN HISTORY 20

The Louvre

Realism in its initial stages endeavoured to take a more commonsense view of the universe than the philosophies of Kant and Hegel Its methods were simple where theirs were complex, empirical where theirs were *a priori* (*see* Lesson 9, Volume 2, page 564, for an explanation of these terms) Taking its problems one by one, it endeavoured to solve them piecemeal, being content with a series of isolated truths instead of seeking to reach the whole of truth ; prepared to study appearances and to abandon the effort to penetrate through to reality Very soon it proceeded to deny that the distinction between reality and appearance was a real distinction It is these movements of reaction and the developments which spring from them that will be considered in this and the ensuing Lessons.

Pragmatism. This is less a system than an instrument for destroying other systems As formulated by William James, Professor Dewey and Dr Schiller, it has become the *enfant terrible* of philosophy, deriding the claims of philosophy to be absolutely true, and even denying the possibility of such a thing as absolute truth. Its leading doctrine is that what we mean by truth is " that which works," that a true belief is simply one that serves on the whole the purposes of the person who holds it; this cuts at the root of our conviction of the existence of objective truth and the possibility of achieving it. At the same time, pragmatism is a philosophy peculiarly suited to the temper of the age It embodies the scepticism, the fluidity of hypothesis and the readiness to adopt provisional views and see how they work, of a generation which takes more kindly to the tentative and experimental conclusions of science than to the dogmatic certainties which religion asks us to take on trust It is also sympathetic to the teachings of evolution, introducing, as it were, a kind of struggle for survival between competing claims to truth and suggesting that the one which seems, or, indeed, *is*, truest is the one which has the greatest survival value

The basis of the doctrine is a certain kind of scepticism Traditional theology has professed to be able to prove the fundamental doctrines of religion Its opponents profess to be able to disprove them. It has subsequently appeared that they are capable neither of proof nor of disproof William James tacitly assumed that there was no evidence one way or the other for religion Yet we must, he held, believe something, if only because we have to act.

James's conclusion is that, although there is no evidence in favour of religion, we may as well, nevertheless, believe it, if we find satisfaction in so doing. All belief, he is inclined to suggest, involves risk, since we cannot know any belief to be true. That being so, the test of the truth of a belief will be not conformity with fact, but ability to work—that is, to serve the purposes which led to the belief being entertained.

The Continuum. William James considers that previous philosophical theories are founded on a false theory of perception. Locke, Berkeley and Hume thought the raw material of sensation was a number of distinct, isolated impressions between which the mind never perceived any connexion. James maintained that it was what he called a *continuum*, i.e., a general confused blur into which the perceiver's mind inserted stops and gaps, thus breaking and cutting it up into the world of separate objects we know. Thus, the relations between things are actually given in experience no less than the things themselves; what the mind does is to make them explicit. The instruments whereby the mind effects this cutting-up process are concepts, i.e., general ideas in the mind which vary according to the interests and training of the perceiver. Two men with different concepts make different cuts across the continuum of experience, and so perceive different worlds of objects. From this it seems to follow that the mind perceives, on the whole and within limits, what the perceiver likes. Pragmatists do to some extent really hold this belief.

Theory of Truth. Pragmatism proceeds to inquire what it is that, on the whole, makes us think a particular belief true. The answer given is that we shall think it true, if it serves our purpose to believe it to be so. We are familiar with the view that religion invents God because men find it necessary to believe in Him, and pragmatism goes on to point out that it is only in so far as it gives emotional satisfaction that any religious belief is entertained. Starting with the position that we think true that which furthers our purposes or gives emotional satisfaction, the pragmatist proceeds to affirm that serving our purposes, or "working" in practice, is the meaning of truth.

In this connexion he takes as an illustration the procedure of the scientist. Scientific theories first appear as hypotheses, which are entertained for just so long as they work, being abandoned when new evidence is discovered which convicts them of

inadequacy. The hypothesis is then modified to embrace the new evidence; the modified hypothesis is found to work—that is, to serve the purposes of the scientist better than the original one—and is, therefore, regarded as true for so long as it does so. Thus scientific theories and even scientific laws are not absolute truths, but are postulates; their truth is continually subjected to review and progressively established by successful tests.

Truth is, thus, provisional and man-made; not something fixed and absolute, but changing as the purposes served by the beliefs that purport to be true themselves change and alter. The more often action on the assumption that a belief is true is found to produce satisfactory results, the truer the belief becomes. Thus, the test of the truth of a belief is not conformity with fact, but success in promoting achievement of desires.

LESSON 20

Realism in Modern Philosophy

THE pragmatist rejects the common-sense meaning of truth as correspondence with fact, partly because he denies the existence of external independent facts with which our beliefs could correspond. This denial springs direct from the conception of the *continuum* (described in the preceding Lesson). If reality is conceived as a confused formless blur, from which the mind carves out objects to serve its purposes, it follows that fact, like truth, is a creation of the human intelligence, bearing upon it the imprint of the purposes the fact was created to serve. All knowing, according to pragmatism, is relative to doing. Hence, knowing a fact involves acting in reference to the fact known; thus to believe in a fact is to alter it. If the belief alters the fact in harmony with our wishes, then, according to the pragmatic theory of truth, the belief in the fact is true, and it follows that the fact asserted by the belief is real. If the belief alters the fact in some way which is not entirely satisfactory, the belief is abandoned and a modified belief is substituted for it. This modified belief will assert a fact of a somewhat different character, which will be more in harmony with the wishes which led us to entertain the belief. Consequently the substituted belief will be truer than the original one, and the modified fact

which the belief asserts more real than the original fact. In this way our beliefs make the facts which they assert. Thus Man is the measure of all things, of reality as well as of truth, the relativity both of fact and belief to our interests and purposes being the underlying thread which runs through the whole of the pragmatic philosophy.

Modern Realism. Realism, a comparatively modern movement in philosophy, assumes many different forms, between some of which there is little in common. All Realists, however, concur in rejecting the idealist view of reality as fundamentally mental in character, and the idealist analysis of the process of sense-perception. Most Realists begin, therefore, by addressing themselves to the problem of perception, with a view to refuting the conclusions of Berkeley and exhibiting the object of knowledge as independent of the knowing mind. Among Realists may be mentioned the English philosophers Bertrand Russell, G. E. Moore, S. Alexander, J. Laird, and C. E. M. Joad; the American philosophers Professors Holt, Perry, and Montagu; and the Austrian philosopher, Meinong.

Consideration will be given to two typical forms of Realism, the first of which results in a view of the world not widely dissimilar from that of common sense; the second, known as Neo-realism, issues in conclusions which are remote from those of the ordinary man.

Common-Sense Realism. It is an axiom with most Realists that in perception the knowing mind is brought into contact with and made aware of something other than itself. This proposition is regarded as self-evident.

For Meinong there are three elements involved in perception: (a) act of knowing, (b) object of the act, (c) content of the act. In any two perceptual experiences (a) is the same, being conceived as a bare activity devoid of features. Yet perceiving a table is obviously a different experience from perceiving a chair. That which makes the experiences different is a difference in the respective "contents" of the two acts, a table content in one case and a chair content in the other, and what makes the contents different is the different objects upon which the acts are directed. But if (a) the act is to be stripped of all features, all the differences between perceptual experiences being referred to (c) the content, (a) tends to become mythological and most

Realists prefer to eliminate it altogether Accordingly, we have theories which postulate only two elements in perception, the act of perceiving (a) which is qualitatively different in any two perceptual experiences, the object (b) on which it is directed

Now, it is obvious that we cannot say that (a) represents *the whole* of (b) to the mind exactly as (b) is otherwise it would be impossible to explain how two people have different perceptions of the same object To meet this difficulty it is necessary to emphasize the activity of the mind in perception This activity is chiefly shown in two ways, the mind selects from the total situation presented to it and goes out beyond that situation Let us suppose, to take an example of Professor Dawes Hicks's, that a botanist, an artist and a colour blind person are each looking at a red rose (R) In view of the differences between the interests of the first two, we may suppose that their attention will be directed to different aspects of what they see, that the botanist will notice aspect r1, and the artist aspect r2 The colour-blind man, owing to the peculiarities of his vision, will again see a different aspect of the whole R, which we will call r3 Now, although r1, r2 and r3 are all different, we are not justified in supposing that they are therefore mental, or that they do not exist in reality as aspects of the whole R All the aspects of the objects that different people see are in fact real and given in the actual situations, but different features of the situation are discriminated in or carved out of the given whole by different perceivers, because of the differences in their training and instincts and the consequent differences in what they attend to

In the second place, the mind obtains fragmentary data in actual perception which it pieces together to form objects If we look at a table, all we in fact see is a couple of legs, the edge of the table top, part of a shiny brown surface, and so forth The table itself we do not see It is the mind which goes out beyond these isolated fragmentary bits of material and puts them together to make a table Different people may piece their perceptual material together differently, also in the process of going out beyond what is given, the mind, which must of necessity make jumps, may fall into error

Endeavours are made by Realists on these lines to account for the fact of differing perceptions, while nevertheless maintaining that what is perceived exists independently of the perceiver

Our Course in Philosophy is continued in Volume 5

LESSON 11

Reaction of Gases to Changes in Temperature

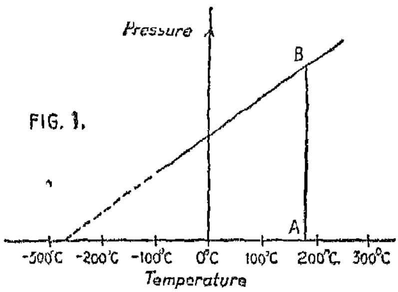
As we saw in the preceding Lesson, the effect of heating a gas is usually considered under two distinct sets of conditions. In the first case, we consider the volume of the gas as constrained to be constant, when common experience leads us to anticipate that there will be a rise in the pressure. In a careful experiment, it is possible to measure the pressure of a fixed volume of gas under different conditions of temperature, and so find the relation between pressure and temperature "at constant volume."

The graphical method perhaps shows the results of these experiments to the best advantage, as seen in Fig. 1. It is clear that the relation may be expressed as a straight line. Actually, if we let P_0 be the pressure at 0° C. and P_t be the pressure at t°C., the relation between these is $P_t = P_0 (1 + \beta t)$, where β is a constant which is equal to $\frac{P_t - P_0}{P_0 t}$. In such instances, therefore, β is called the "coefficient of increase of pressure at constant volume." Experiment shows that this is a constant, having a value of about $\frac{1}{273}$ (·00366). Examination of the curve shows that it would intersect the axis of temperature at − 273° C. approximately. This is also seen if we consider the equation. For example, when $t = -10°$C., $P_t = P_0 (1 - \frac{10}{273})$, and when $t = -273$, $P_t = P_0 (1 - \frac{273}{273}) = 0$.

The temperature of − 273° C. seems to be one at which gases, *if they remained gases*, would have no pressure. More of this is said in the next section. Before we leave this "pressure-temperature" relation, however, there is a point which will be apparent. If we enclose a volume of gas and always maintain its volume constant, we can use the pressure-temperature curve to measure unknown temperatures. This is the principle underlying the *constant volume gas thermometer*. The pressure at melting ice temperature and the pressure at boiling water temperature (boiling at a pressure of 76 cms. of mercury) are taken as the "fixed points." The size of the degree is $\frac{1}{100}$ of this "funda-

mental interval," and is very rarely the same as the ordinary Centigrade mercury thermometer unit. If the bulb which contains the gas is placed in an unknown temperature enclosure, and the pressure to maintain the volume constant corresponds to, say, AB (Fig. 1), the temperature can be read off the curve to be about 185° C. This type of constant volume thermometer has been used in the past to measure high temperatures.

FIG. 1.



Constant Pressure. The second method of studying the effect of temperature on gases is to maintain them at constant pressure and examine the change which takes place in the volume of the gas. Experiment shows that the volume at constant pressure is related to the temperature in a way similar to the pressure variation at constant volume. In fact, if we plot volume against temperature we have a curve identical with that of Fig. 1. The equation which shows the volume-temperature relation is

$$V_t = V_0 (1 + \alpha t)$$

where V_t is the volume at t° C. and V_0 is the volume at 0° C. Further, the value of α is found by experiment to be $\frac{1}{273}$ very nearly, so that it would appear that, if a gas remained as a gas as the temperature was lowered, it would have no volume at all at -273° C. This temperature is, therefore, called the absolute zero; and a scale of temperature, called the gas scale or absolute scale (A°), is used. This has its zero at -273° C., and the size of degree is the same as on the Centigrade gas scale. Thus 0° C. is 273° A. (absolute); again, 100° C. = 273 + 100 = 373° A.; t° C. = $(273 + t)^\circ$ A., and may be written T°. (It is customary to use capital letters to indicate absolute temperatures, i.e. temperatures on the absolute scale). Considering only the constant pressure changes, we have:

$$V_t = V_0 \left(1 + \frac{1}{273} t\right) = V_0 \left(\frac{273 + t}{273}\right) = V_0 \frac{T}{T_0}$$

where T = 273 + t and is the equivalent of t°C. on the absolute

scale ; T_0 is the equivalent of o° C. on the absolute scale. This is often written :

$$\frac{V_t}{T} = \frac{V_0}{T_0}, \text{ or } \frac{V}{T}$$ is a constant, which is another way of saying that V is proportional to the absolute temperature. This is called "Charles' Law," and was also discussed in the Chemistry Lesson in Volume 1, page 171, as it is always used when dealing with the volume changes with temperature. We must now, of course, remember that at low temperature gases are liable to change to liquid, and that the above relations do not apply when we have a change of state of this kind.

Liquids and Vapours. When water boils it changes to steam, a gaseous form of water. Even at ordinary room temperatures water evaporates and forms a vapour, as we know from the fact that water in an open vessel gradually disappears. If we have a closed space and introduce a small drop of water into it, we have a vapour which is *unsaturated*. This obeys Boyle's Law and Charles' Law. If now we introduce more and more water, we finally come to a state when the water does not evaporate into the *closed* space any further. We say that the space is saturated with water vapour. We discussed this in terms of the molecular theory in Lesson 8 (Vol. 3, p. 573), and saw that the unsaturated vapour is due to quickly moving molecules leaving the water. In the saturated state the molecules still leave the water, but as the closed space has as many molecules in it as it can contain at that temperature, we have as many returning to the liquid as leave it in a given time. Both saturated and unsaturated vapours exert a pressure, as may be shown by using the space above the mercury in a barometer tube as the "closed space" referred to in the above paragraph. If water is introduced, drop by drop, in the "Torricellian vacuum" above the mercury, it is found that the mercury is depressed owing to the pressure of the water vapour.

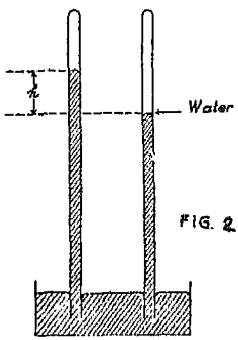


FIG. 2

Finally, when sufficient water has been introduced to saturate the space, as judged by the fact that a little water remains *as such*

on the mercury surface, it is found that the water vapour—called the *saturated* water vapour—exerts a maximum pressure at the temperature of the experiment. This is called the saturated vapour pressure. It can be measured in the way indicated in Fig. 2, where the left-hand barometer is an ordinary one and the right-hand tube contains free water over the mercury. The length h is the saturated water vapour in cms. of mercury at the temperature of the experiment.

If the temperature rises the saturated vapour pressure gets bigger and, finally, for water, when the temperature is raised to 100° C., when the barometer reads 76, the water boils and the mercury in the tube is forced down to the level of the mercury outside. In other words, the saturated vapour pressure becomes equal to the outside pressure. If the barometer is low it is not necessary to heat the tube to 100° C. to bring this about. That is to say, the water boils at a lower temperature than 100° C. This is true in all cases. Take, for example, the case of water boiling up a high mountain, where the atmospheric pressure is always much less than 76 cms. of mercury: the boiling point of water is correspondingly low—it might be as low as 94° C. On the other hand, if the pressure is increased the boiling point is raised. This is accomplished in boilers, "digestors" and the like, where the steam is not allowed to escape until the pressure is high enough to open a valve at a set pressure. The temperature can, in this way, be raised to quite high values due to the steam pressure.

It will be seen now why we found it necessary to stipulate the atmospheric pressure when talking about the upper fixed points of a thermometer, as water boils at 100° C. only when the pressure is 76 cms.

Liquefaction of Gases. All the gases we have regarded in a general way as being the natural state of the element concerned, e.g. oxygen, nitrogen, etc., can be considered simply as unsaturated vapours of the corresponding liquid state. The so-called "permanent gases" are no exception to this rule. If we take the proper steps, we can convert them to saturated vapours and liquefy them.

Some gases respond to the same treatment as saturated vapour of water—simply cool them. Others can be liquefied by pressure only (e.g. sulphur dioxide), but in the latter case the gas must be below a temperature which is critical to the gas itself. At ordinary room temperatures, for example, sulphur dioxide may be

liquefied by pressure only because it is below its *critical temperature*. Many early attempts at liquefaction of gases were carried out without success, as the critical temperatures of the gases concerned were below the temperature of the room, so that in spite of the ingenious and dangerous efforts of the experimenters in producing really large pressures, no success attended their efforts.

We realize nowadays that no pressure, however great, can bring about liquefaction, unless we first cool the gas below its critical temperature. There are many ways of doing this. The simple method of producing a small amount of cooling is to use a freezing mixture. Ordinary salt, calcium sulphate, etc., when mixed with ice, reduce the temperature below zero, but not *very* much below. However, this temperature (15° to 16° below zero) can be used to liquefy certain easily liquefied gases, and the liquids so formed may be used to produce cooling in other gases, and so on.

To produce a really appreciable drop in temperature the method which has been most utilized is the expansion of compressed gas. It is well known that if we compress a gas we produce a rise in temperature; all who have pumped up a bicycle tire will have experienced this effect. Conversely, if we allow the compressed gas to expand suddenly it cools. So if we compress a gas —say, air—and cool it as low as possible by surrounding it with a low temperature bath (freezing mixture, liquefied carbon dioxide, etc.), and then allow it to expand, it will cool still further. This process is used to liquefy oxygen, nitrogen, the mixture called air, etc.

The gas is raised to a pressure of many times that of the normal atmosphere and is then cooled and led through a metal spiral tube contained within a second spiral tube. By means of a pin valve the highly compressed gas is allowed to expand and so become cooled. The cool gas passes into the space between the two tubes, and reduces the temperature of the oncoming compressed gas in the inner spiral tube. This cooled gas is then allowed to expand and cool still further. The process is repeated continuously until, finally, the expansion results in the liquefaction of the gas. This method is called the regenerative cooling process. At a temperature of −183° C., air was liquefied (i.e. at 317° of frost on the Fahrenheit scale) and in turn the so-called permanent gases yielded to this form of treatment, and, finally, helium, the last of the gases, was converted to a liquid. Recently at Cambridge a large plant was installed for the production of

supplies of liquid helium so that certain physical investigations could be made at the extremely low temperature of this liquid ($-269°$ C.)—at a temperature sufficiently low in fact, to be approaching the absolute zero (it is actually about $4°$ A.). At these very low temperatures matter takes on very interesting properties. Electric resistance, for example, becomes exceedingly small, and the metals become "super conductors"—a well-earned title in this case If a ring of metal at the temperature of liquid helium has an electric current induced in it, the current goes on flowing for days We shall return to this question later.

An interesting outcome of the production of these liquids at such low temperature was the fact that at ordinary temperature the liquids were well above their boiling point, and consequently they boiled away with extreme rapidity Liquid air, for example, when placed on ice behaves in the same way as would water placed on a dull red-hot metal. Dewar, who was the first to produce liquid air was confronted with the problem of how to store the liquid when he had produced it; he solved the problem by making the Dewar flask, also called the thermos flask For the moment we can assume that the liquid can be stored, and briefly consider what properties ordinary matter has when at the temperature of liquid air

Most substances change their elastic properties. For example, a bell made of lead is useless at ordinary temperature, but will ring with a good clear note when cooled down in liquid air At this temperature a lead spiral acts like a spring and will support a weight. flowers become brittle and may be easily powdered into fine dust; grapes, meat, india-rubber, etc., all become brittle and may be smashed into a thousand pieces if hit by a hammer when at this temperature Even mercury becomes a hard solid; the writer has often moulded mercury into the form of a hammer, and used this hammer, made of mercury frozen solid in liquid air, to drive nails into wood. If these things happen at such a temperature as $-183°$ C., it is clear that we can "expect the unexpected" at $-269°$, the temperature of liquid helium, and it seems that much useful information will be obtained by the experiments at these extremely low temperatures.

LESSON 12

Three Methods of Heat Conveyance

In the previous Lesson we considered the production of very low temperatures and the liquefaction of so-called permanent gases. We found that, when air was liquefied, there was a great difficulty in storing it, as it so rapidly boiled away at ordinary temperatures. The thermos flask, which Dewar invented to overcome this difficulty, attains its object because in the design steps were taken to eliminate all gain of heat from the outside by the liquid kept within it. Most of us have used a thermos flask and know that we can keep hot liquids within it at a high temperature, and cold liquids at a low temperature.

What Dewar really made in this flask is a good thermal insulator, i.e. he was able to cut down to a minimum all heat transference to the inside of the flask. To understand how this is brought about we must be acquainted, as he was, with the methods by which heat can pass from one place to another, and so see how to prevent its passage. We recognize three general methods by which heat is conveyed from point to point; these are known as the methods of *conduction*, *convection*, and *radiation*.

Conduction. In conduction the random agitation ($\frac{1}{2}mv^2$) of the molecules of the substance conveying the heat passes from molecule to molecule through the mass of the substance, whose temperature rises in consequence along the length of the conductor of heat. A good example of conduction is to be had if a poker is left in a fire. The end remote from the fire becomes hot; we know also that the intermediate parts of the poker are hotter, i.e. we recognize that there is a drop in temperature along the length of the poker. In fact, the thermal agitation passes from molecule to molecule, and so the temperature rise spreads. Substances behave differently in this respect. We have good conductors of heat (e.g. silver, copper, and the metals generally) and bad conductors of heat (paper, wood, etc.). As an example of a bad conductor perhaps the most obvious is the case of wood. An ordinary match when burning can be held until the flame is almost at the fingers, but no discomfort is felt, as the wood is a bad conductor of heat. Asbestos packing is used round hot-water

pipes and some of the newer hot-water storage tanks, because it is such a poor conductor of heat, and so enables the hot water to be stored with very little loss. Glass is another bad conductor. Certain silver teapots are highly decorative, but, when provided with silver handles, are extremely unpleasant to hold, because silver is one of the best conductors of heat and so the handle becomes very hot. On a cold day we again find common examples in the difference of *thermal conductivity* of different substances. If we touch a metal object it seems *very* cold, as heat is conducted from the hand via the metal ; whereas, if we touch a wooden object, which we know is at the same temperature, it feels much warmer, because heat is not conducted away by the wood.

Convection. Liquids, generally speaking, are very poor conductors of heat. If we take a test tube and fill it with water, weight a piece of ice so that it sinks to the bottom, and then apply a flame to the upper part of the water in the tube, we can boil the upper layer vigorously without having any appreciable effect on the ice in the lower cold layer.

In this experiment it will be noticed that the heat is applied to the *top* of the liquid and any thermal conductivity is downward. This was done deliberately, because, when heated from below, the temperature of the water is raised by another process called *convection.* This is the method whereby liquids and gases are most often heated. The lower layers, when in contact with the supply of heat, naturally become hotter ; they expand, and so, becoming less dense than the rest of the fluid, they rise within it and carry the hot portions bodily through the rest. To take the place of the hot fluid, cooler fluid sinks and, in turn, becomes heated, until the whole mass acquires a higher temperature. In convection it is seen that there is this bodily movement of the heated fluid. It is not a case of passing on the temperature rise from molecule to molecule, but rather a movement of the agitated molecules yielding place for the slower moving ones to come in contact with the heat source and so be raised in temperature.

This process of convection is the cause of land and sea breezes, considering a large-scale case. In summer, when the sun shines on land and sea, the land, of low specific heat, becomes hotter than the sea. The air in contact with the land rises and colder air from over the sea comes in, as a sea breeze, to take its place. At night, when there is cooling, the land cools quicker than the sea, and so the reverse process takes place and causes a land breeze.

If the circulation of the air is stopped this method of heat transference is eliminated. As an example of this, we notice how much quicker a pan of water boils when the lid is on than when the pan remains open and allows a continuous convection of the heat from the surface of the water.

Radiation. Both the methods of heat transference we have considered depend on the presence of some form of material substance. If the hot body could be supported by a fine thread of a very bad conducting material and be placed in a vacuum, the heat-loss by these two methods could be practically eliminated, and yet we should find that the temperature of the body would fall. The reason is that it loses heat by the process of radiation. It would appear from what has just been said that heat in the form of radiation may be transmitted without the help of any material medium; this is the case, and is the important distinguishing feature of the process.

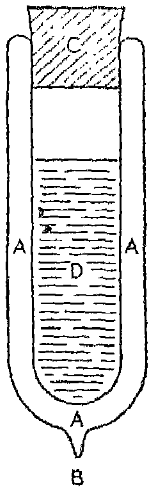
Perhaps the best example of radiation, and certainly the most important to us, is the passage of the heat from the sun to the earth. We know that there is no material in the vast interstellar space through which the heat in the sun's rays passes on its long journey to us. Further, it is common observation that when material media do intervene, the amount of heat received is appreciably diminished—for example, when a cloud intercepts the sun's rays there is a marked drop in temperature.

During an eclipse of the sun another piece of information about radiation of heat may be obtained. It is most noticeable that the instant the light of the sun is cut off there is a pronounced drop in temperature. This suggests that the heat from the sun comes to us at the same speed as the light, and that it does so in a straight-line path. On a small scale, we have ample evidence of the fact that heat travelling in the form of radiation does so in straight lines if we consider the radiation from an open fire. The moment a solid object is placed between the fire and ourselves all radiation is cut off, and we recognize in the question, " Can you *see* the fire?" that this is so, and also that the radiation from it follows the same laws as light in this respect.

A simple experiment which many of us have performed shows that the heat which is radiated obeys other laws which are followed by light. A lens is used to " focus the sun " on to a piece of dry tissue paper or dry leaves; after a little time the dry object commences to smoulder and finally takes fire. This shows that

the light and the heat are equally bent by the lens, or, as is said, the *refraction* of the two is the same. Incidentally, many fires have been accidentally started by the sun's rays passing through a tumbler of water or pieces of broken bottle, and producing the same effect as the "burning glass" just referred to in the example quoted. There is no doubt, therefore, that the radiation obeys almost all the laws which are applicable to light.

Loss of Heat by Radiation. An important consideration in the loss of heat by radiation is the nature of the surface of the hot body. If the surface is black and matt in character the loss of heat by radiation in a given time is great compared with the loss from a similar body with a brightly polished surface. If we take two copper balls of the same size and at the same temperature and polish one brightly and deposit soot on the other and then hang them in front of a fire by a thin thread, it will be found that the black one absorbs most heat and is, therefore, hotter after a given time. It is a general law that good absorbers are good radiators, and good reflectors are bad radiators and bad absorbers, as they reflect the radiation instead of absorbing it.



SECTION OF THERMOS FLASK. A, vacuum; B, seal; C, cork. D, liquid.

We can now summarize the three processes by considering the example of the thermos flask, which drew our attention to this subject. A section of a thermos flask is shown in the diagram. It consists of a double-walled vessel of thin glass, which is a bad conductor of heat. The air between the walls (A) is pumped out and the tube is sealed from the pump at B. The "vacuum" has no appreciable gas left in it, and so convection is stopped. The inner faces of the walls on the flask are silvered, and so, if the liquid (D) is hot, it is in a bad radiator. Any heat which is radiated is reflected back by the outer walls, and so radiation is practically eliminated. It is most important to have a cork (C) to stop convection above the liquid, and, finally, the minute amount of heat conducted along the glass walls is the only other loss. This flask, therefore, embodies all the necessary steps to eliminate heat transference, so that, whether (D) is hot or cold, it remains so for very considerable periods.

LESSON 13

Some Properties of Wave Motion

In the preceding Lesson it was stated that the heat from the sun reaches us "in the form of waves." These waves were said to be like light waves, and to follow the same laws In physics we often meet with examples of energy being transmitted in a wave form, and it seems desirable at the outset to have a clear idea of what is implied in the term "wave motion"—how it travels, and the like

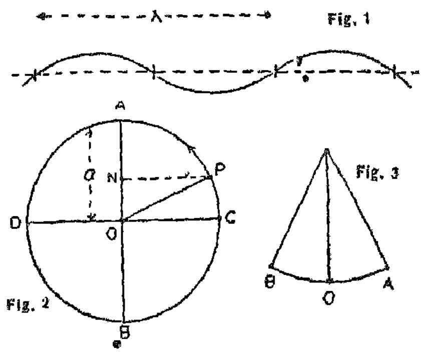
The first reference to waves, no doubt, brings to our mind a picture of waves on the sea, where we have a very direct visual evidence of the up and down movement of the water and the bodily movement of the form which we call a wave One thing which this example shows clearly is that, in the wave motion, any part of the water through which the wave travels is not moving with the wave For example, if we watch a boat on the sea, it moves up and down as the wave passes it, but it does not move bodily with the wave In our early days we were a long time in learning this lesson We all have recollections of sailing toy boats, and our attempts to bring them to shore by throwing stones All that results is this. the stone produces waves, and the toy boat rides up and down on the water surface without making any attempt to move to the shore with the wave motion. Most of us, on occasions, have repeated the attempt to reclaim our becalmed craft by this impossible method

Let us examine the simplest form of wave of the type referred to, and see if we can find out how it is produced and propagated. We will think of a case simpler than water waves for example, waves on a stretched cord or string. If we tap a stretched string (e.g a long clothes-line) the tapping produces a depression in the string which travels as a wave along the length of the string until it reaches the other end, where it is reflected back again. The tapped part of the string comes back to the original position in time, i.e. the string, like the water waves moves up and down. The depressed part does not go along the length of the string, although the wave motion does so. If, instead of tapping the

cord, we move one end up and down, the wave continues to travel along the length of the string. We have, no doubt, performed this experiment with a skipping rope, "making snakes" with the rope When one end of the rope moves up and down, this causes the next piece of the rope to move in a similar manner, and the movement, if maintained at the first end, continues along the length of the rope. The beginning of the wave, therefore, is the up and down movement of the "medium" in which the wave is transmitted.

The best known movement of this type is called *simple harmonic motion*. The bob of a pendulum is a good example of this. The physicist's simplest illustration of the production of simple harmonic motion (S H.M.) seems rather arbitrary, but is, nevertheless, worth considering, as it does give useful help in considering waves

Simple Harmonic Motion. If we consider a point, P, to move round a circle with a constant speed (*see* Fig. 2), it will go from A to D, D to B, B to C and C to A in equal times. Now let us imagine that from P, at every point it occupies, a perpendicular PN is drawn on to the diameter AB. Then it is clear that as P moves round the circle, the foot of the perpendicular, N, moves up and down the diagonal. If we start with P at A and let it go round the circle once, N will start at A and go down to B, and, in fact, will be at point B when P is there, and as P goes along BC, N will move along BO and finally come back to A when P reaches this point. N will complete one "there and back" movement whilst P makes one complete circuit. The time for this will be fixed, of course, if we



WAVE MOTION, Fig. 1. Simplest form of wave transmission **Figs 2 and 3.** Diagram illustrating what is termed simple harmonic motion; an explanation of the lettering is given in the text.

back" movement of N. N is said to oscillate with simple harmonic motion.

This simple harmonic motion has an extreme *amplitude* OA or OB $= a$, say. The time taken for the point N to go from the position of rest O to A is T/4 : after a second T/4 the point N is back again at O : then, in a further T/4, it is at the other extreme at B, and so on. If we consider the example of S.H.M. as provided in the simple pendulum, we see in Fig. 3 that OA $=$ OB is the amplitude, and the time taken whilst the bob goes from O to A, back through O to B, and finally to O again, is the periodic time T, which, incidentally, is equal to $2\pi\sqrt{l/g}$; the point to be noticed is that the bob passes through O twice, once in each direction, and we agree to call T the time taken from one transit to the next *in the same direction.*

Let us consider the motion in a little more detail. If we start with the position o for P the foot of the perpendicular N is at O, in Fig. 4. The circumference is divided into 12 equal parts; therefore the time taken for P to go from one of these points to the next is T/12. When P is at 1, N is at A; when P is at 2, N is at B, and so on. It is clear that when P is at 3, N is at C (the same point), and is for the moment at rest whilst the direction of movement changes. At O, on the other hand, the velocity of N is greatest.

Now let us consider a row of particles, S, T, U, V, W, X, etc., all oscillating with simple harmonic motion of the same amplitude a and periodic time T. In fact, let the left-hand part of the diagram (Fig. 4) be the key to give the positions of all the particles. If all start at rest and move upwards, they will all bodily advance to the first, then second, and then third dotted line position, and so on. If, on the other hand, they do not start together, but if we arrange that the particles each have a start of T/12 over their right-hand neighbour, we obtain the result we are requiring.

For example, S moves to position 1, and so gets T/12 start: when S moves to position 2, T moves to position 1 : when S moves to position 3 (i.e. $3\frac{T}{12} = \frac{T}{4}$), T moves to position 2 and U moves to position 1 : S now moves back to position 2, T moves to position 3, U moves to position 2 and V moves to position 1.

Finally, when S gets back to its original position at S, the other particles are in the positions shown in the wave line of the diagram.

Draw a row of 12 equally spaced dots instead of S.T., etc.,

and carry on with this, moving each in distances as given by the key diagram, and you will find that the result is a wave which moves from left to right, although you only make each particle move up and down with S.H.M., differing in starting time by T/12. We say that there is a difference of *phase* between the motion of the particle S, T, U, V, etc., of an amount corresponding to T/12. The phase difference is usually represented by the angle which the tracing point has gone in the time, i.e. 360 (angle gone in time T) $\div$ 12 = $\frac{360}{12}^{\circ}$ phase difference.

The important part of all this is that we have very conclusive evidence here that a wave motion is produced by a row of

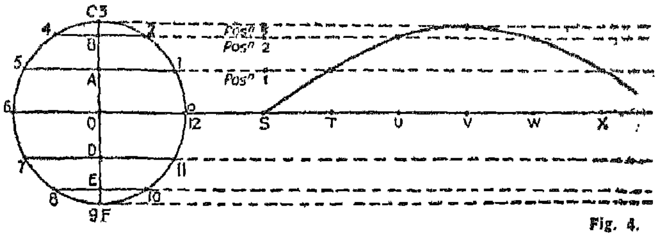


Fig. 4.

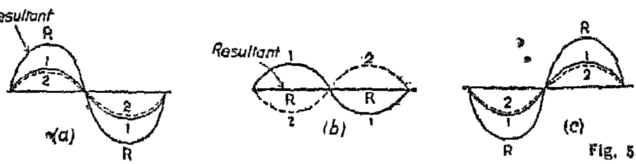


Fig. 5.

Fig. 6

WAVE MOTION. Fig. 4. Detailed diagram illustrating simple harmonic motion. Figs. 5 and 6. Diagram showing production of interference of waves.

particles vibrating with S.H.M., when equal phase differences exist between adjacent particles. In the case taken in the illustration, the particles are vibrating in one direction and the wave is transmitted in a direction at right angles. This kind of wave is called a *transverse wave*. There are many examples of this type in addition to the obvious ones we have considered, namely the waves on a stretched string, water waves, etc. There are the less obvious cases of light waves, wireless waves, radiant heat waves, etc.

If the particles S, T, U, V, etc, were made to vibrate in a direc-

tion parallel to SX, i e at right angles to the direction taken in Fig 4, waves of a different character called *longitudinal waves*, would be produced The best example of this type of wave is the ordinary sound wave, and we will return to this problem later

Transverse waves are easier to visualize and easier to illustrate by diagram, so we will continue in our investigation of wave properties with this type

Interference of Waves. We will return to the illustration of the long skipping rope fastened at one end and shaken at the other For one sharp jerk we saw that the pulse or wave set up may be sent back or reflected from the fixed end If we make the tension on the rope fairly large (i e pull on the rope) and continue to move the end up and down with sufficient speed we find that the waves which we are sending along it and the waves which come back commence to act on each other, and in time, with suitable oscillation of the free end the rope seems to take up a stationary form of one, two or more loops and there is no longer a wave *progressing* along the rope This is called a *stationary wave* It is brought about by the interaction of the two wave trains—the incident and the reflected This interaction is of course to be expected For, suppose that the two sets of waves are so arranged that the crest and troughs of each fit together, the effect will be a double amplitude If the crest of one comes with the trough of the other, the two waves just neutralize and there is no motion at all

This is indicated in Fig 5, which shows (a) two waves fitting crest to crest and trough to trough, and R shows the resultant with double amplitude Fig 5 (b) shows waves 1 and 2 with crest to trough, and R is the resultant This shows that if two waves are sent in the same direction with equal amplitude, but with 180° phase difference, (b), the result is just as if no waves were present

If the waves go in opposite directions, they are first as in Fig 5 (a), then as in (b), then as in (c), then (b) and then (a), etc, i.e., they form stationary waves which are illustrated in Fig 6

Another way in which waves can react and produce what is called interference is illustrated if we take a flat dish and fill it with water. Two identical tuning forks have each a small bristle attached, so that when the forks vibrate the bristles set up little waves on the water surface If one fork only vibrates there is set up a series of concentric water waves When the

other fork vibrates the waves, it sets up interference with the first set, and lines marking positions of no movement of the water can be seen. In fact, if at any place one wave causes a crest and the other a trough, there is no *net* movement, provided the amplitudes are the same.

When a wave approaches an obstacle it may behave in one of two ways; either it will be stopped or reflected, or, alternatively, if the obstacle is a small one, the wave can bend round it. This is well illustrated in sea waves. If a sea is running towards a long breakwater, we notice that near the end of the breakwater wall there is a slight movement, but within the "shadow" of the wall there is no appreciable movement. On the other hand, if we watch a little farther from the shore, the same sea approaching a large rock, there is no appreciable shadow; the waves, in fact, appear to bend round the obstacle.

All these properties of waves which have been dealt with in this Lesson will, of course, be expected in any wave motion. If light, "waveless" waves, etc., are true waves, they must exhibit these properties, and it will be seen in the last Lesson on light that, if we have the right conditions, we do, indeed, obtain analogous results with light.

LESSON 14

Light and the Laws of Reflection

BEFORE we proceed to discuss the physical nature of light, on the lines indicated in the preceding Lesson, we should consider certain simple properties of light. We shall be able to put into the form of laws, or rules of play, many facts which all appreciate in a general way already. Forgetting for the moment that we are later going to show that light travels as waves, the first thing which we notice is that light travels in a straight line path. If we have a very small bright light source, and we put an object between this and a white screen in a room where no other light can enter, we know very well that a shadow will be formed on the screen which has a shape identical with that of the object casting the shadow. This is consistent with a straight line path for the light, or with "rectilinear propagation" of light, as it is called. We have met this simple experiment in the amusing animal shadows cast by the hands.

If we use a large source of light we do not get this sharp outline; there appears to be a double edge to the shadow, which has a black centre of the shape of the object, and this is edged with a half shadow, of the same outline This is again consistent with rectilinear propagation of light In Fig 1 let AB be a large source of light illuminating a screen and let the object be a ball. If light travels in straight lines from every point in the source, then it is clear that from A the light will go to the screen and the rays AP and AQ will just skim the object. On the screen we have no light between P and Q from A, and PQ would be the diameter of the black shadow if A was the only illumination.

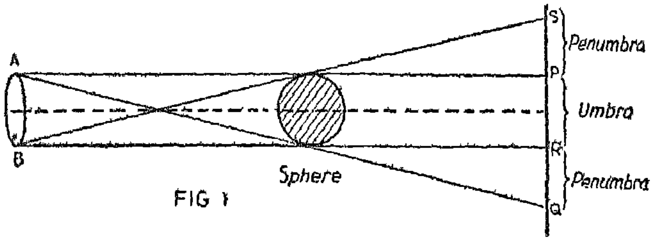


FIG 1

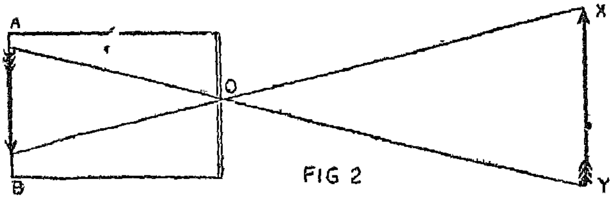


FIG 2

Figs 1 and 2 Experiments to show that light travels in straight lines

Going to the other extreme of the source, it is equally clear that SR is the shadow cast by the sphere with regard to the light from B. The region PR is in the shadow from both ends and also for all the points in the source All points on the screen above S receive light from all the sources, from S to P the screen is illuminated by a less and less fraction of AB, and finally at P it does not receive any light at all. The same happens in the under half of the shadow. We, therefore, obtain a circular black shadow (umbra) (PR) at the centre of a circular partially black shadow (penumbra). On a large scale, if AB is the sun, and the object casting the shadow is the moon, the resulting eclipse of the sun as seen from the earth is total if the earth happens

to be within the region PR, or partial if in the region SP or RQ. From our present point of view the experiments referred to are only used to show that the light does travel in a straight line, i.e., the results obtained agree with the above explanation in terms of straight lines.

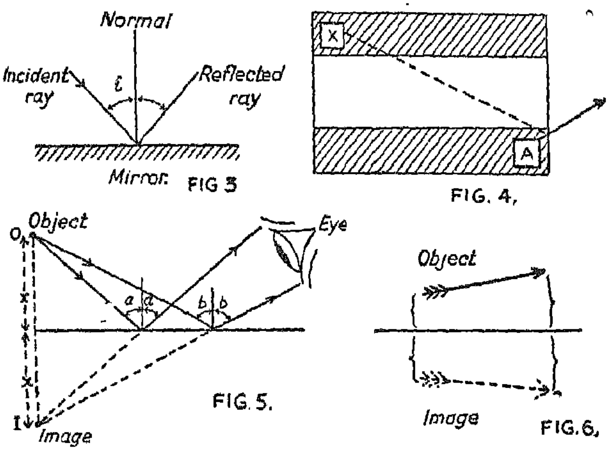
Of the many simple experiments which may be quoted to add support to this is that of the simple pin-hole camera (Fig. 2). A pin-hole O is made in the centre of a light-tight box, and the other end has a ground glass end AB. When the box is pointed at a brightly illuminated object, represented in the diagram by the arrow XY, an inverted image of the object is produced on the glass screen. The straight lines show the path of the light rays which produce the image. If a photographic plate is placed in a box, instead of the ground glass sheet, an excellent photograph is produced, provided that a long enough exposure is given. The time taken depends on the size of the hole. Something of the order of two hours' exposure is usually required, so that the pin-hole camera is only suitable for stationary scenes. But as indicated, it works because the light travels in straight lines from the object through the hole to the plate.

When light falls on a mirror it is reflected, and the direction before and after reflection are simply related. The straight lines which have been used in the diagram are called rays. We call a bundle of rays together a beam of light. For the simple treatment we will consider rays only.

If a ray of light falls on a mirror it is reflected from the mirror in a direction which depends on the angle at which the incoming light strikes the mirror. We call the incoming ray the incident ray, and the outgoing ray the reflected ray. We imagine a line drawn at right angles to the mirror at the point of incidence; this line we call the *normal at the point of incidence*. The angle between the incident ray and the normal is called the angle of incidence; the angle between the normal and the reflected ray is called the angle of reflection.

Laws of Reflection. Experience shows the truth of the Laws of Reflection, which are (1) the incident ray, the normal at the point of incidence, and the reflected ray are all in one plane; (2) the angle of incidence is equal to the angle of reflection. We all realize the truth of these laws, which are actually a statement of the results of many experiments. They really embody what we regard as common experience. For example, if you are in a

train at night-time, when the windows act as mirrors, and you are at position A, in Fig. 4, which represents the plan of your carriage, and at X there is someone you think you know, but there is an uncertainty which precludes direct observation, the obvious thing to do is to apply the Laws of Reflection. If you look out of the window so that the normal at the point of incidence is in a plane containing A and X, and the direction at which you appear to be examining the outer darkness is shown by the arrow, you are actually choosing a direction such that the dotted line and your direction are equally inclined to the



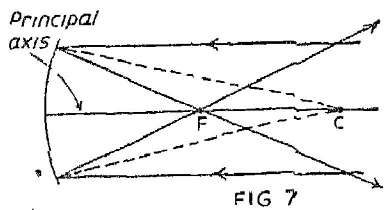
Figs. 3—6. Illustrating the Laws of Reflection.

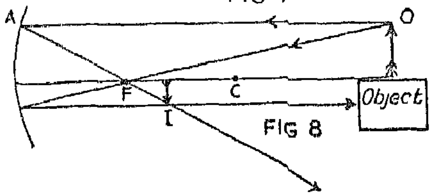
window, and, of course, you see the person at X apparently outside the window.

In all cases of reflection in plane mirrors the object we look at is reproduced as an image in the mirror. This image does not exist, but the eye takes in a beam of light that appears to diverge from an image, as far behind the mirror as the object is in front of it. This type of image is called a *virtual* image, and in a plane mirror it is the same size as the object. When we have a large object it produces a virtual image in a plane mirror (Fig. 6).

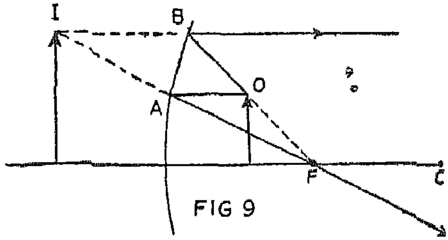
If we use curved mirrors we get other results. For example, if we take mirrors which are parts of spheres and silver them, we can produce either concave mirrors (the inside of the spherical

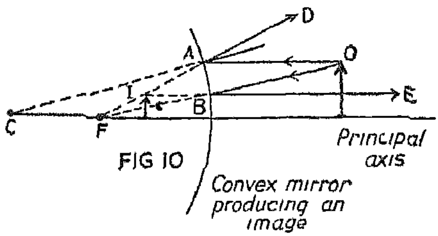
surface reflects), e g shaving mirrors or convex mirrors (the outside silvered and reflecting) e g motor car reflector mirrors In these cases the image is not always virtual and is not, in general as far behind the mirror as the object is in front





The way in which we find the position of the image produced in either type of spherical mirror is to apply the Laws of Reflection to the rays which leave the object For example in Fig 7 the centre of the sphere of which the mirror is a part is at C and is called the centre of curvature





Figs 7–10 Illustrations of the Laws of Reflection

When a parallel *set of rays falls* on the mirror—say, from the sun—the normal to the mirror is the radius, i e the line joining the point of incidence to C, and the ray is reflected at an equal angle on the other side It is found that for small mirrors the reflected rays all pass through F, which is called the principal focus and is nearly half-way from C to the mirror In the same way if we reverse the rays we can see that all the

rays passing through F, on their way to the mirror, after reflection go out parallel to each other and to the principal axis

For example, if C is the centre of curvature and F the principal focus, an object placed at O, as in Fig 8, will produce at I an image which is inverted and smaller than the image The position of I is obtained by drawing a ray, parallel to the principal axis, to A, after reflection it goes through F A second ray incident through F, after reflection goes out parallel to the principal axis and intersects the first ray at I, causing the brightness which is associated with the image If we were to place a screen at I an image would be formed different from the virtual images formed by plane mirrors This is called a *real* image

It is also clear that if an object were placed at I, its image would be at O it would be inverted and real This is exactly what happens in the optical illusion called the "phantom bouquet" A vase is placed at O, and a bunch of flowers is placed upside down at I and is illuminated on the mirror side Everything except the vase is hidden in a black screen When viewed in any direction, except that of the principal axis of the mirror, the vase appears empty, but when viewed along the axis, the real image of the flowers is exactly on the top of the vase and gives the illusion of a vase full of flowers, which disappear when the eye moves from the line of the axis

If the object is placed nearer to this type of mirror than the principal focus the image produced is no longer upside down or real. It becomes virtual, and of a size greater than the object which depends on the distance from the mirror to the object.

In Fig. 9 an object is placed at O the two rays are drawn and, obviously, appear to diverge from I, which is, therefore, the virtual image of O It is noticed that the image is bigger than the object The concave mirror used as a shaving mirror acts in this manner, and the enlarged image produced is supposed to ensure a better view of the chin and so help to obtain a better result

The convex mirror always produces virtual images of smaller size than the object and, therefore, allows a much larger field of view to be appreciated at once This explains their use as reflecting mirrors in motor-cars When light falls on this type of mirror parallel to the principal axis it reflects away and appears to come from the principal focus (e g. in Fig 10 OA incident reflects to AD) Here, again, a ray directed to F reflects away parallel to the axis. (OB, directed on F, reflects along BE.)

Both rays appear to come from I, which is the diminished virtual image of O. The farther away the object is from the mirror the nearer to F is the image. So in a car reflector mirror a second car approaching from behind gradually gets bigger in size as its image moves from near F to the mirror itself.

In mirrors of both kinds we are able to calculate the position of the image if we know where the object is and also the focal length of the mirror (i.e. the distance from F to the mirror). We have not space to discuss this in detail but we may take it that if the image distance is v, and the object distance u, and the focal length f, then

$$\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$$

provided that we call distances on the object side of the mirror positive and those on the other side negative.

Thus suppose we have a concave mirror of focal length 15 cm. and an object is 40 cm. away, the image is produced a distance v away such that

$$\frac{1}{15}=\frac{1}{40}+\frac{1}{v} \text{ or } \frac{1}{v}=\frac{1}{15}-\frac{1}{40}=\frac{8-3}{120}=\frac{5}{120}$$

or $v=\frac{120}{5}=24$ cm. (i.e. on the same side as the object and therefore, *real*).

For the same mirror an object 10 cm. away has an image v′ away, which is given as before

$$\frac{1}{15}=\frac{1}{10}+\frac{1}{v'} \qquad \frac{1}{v'}=\frac{1}{15}-\frac{1}{10}=\frac{2-3}{30}=\frac{-1}{30}$$

or $v'=-30$, this means 30 cm. on the other side, and, therefore, the image is virtual.

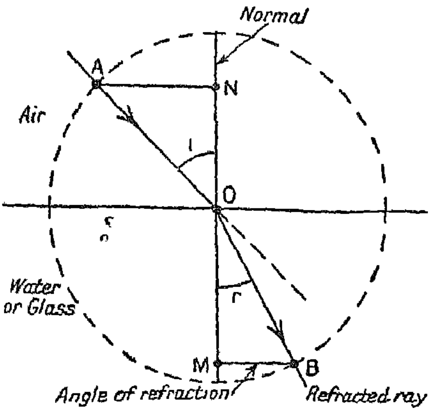
LESSON 15

Concise Survey of Refraction

In the previous Lesson we studied the reflection of light at prepared mirrors which give good reflection because of the opaque silvering which backs them. As we know from

landscape reflected in it, and at the same time we see objects beneath the water surface In the same way, if we were to swim under the water with our eyes open, we should still be able to see the landscape which the water surface reflects. In other words, the surface reflects part of the light and transmits the rest. The rays of light which penetrate the water do so, in a direction different from that of incidence, and we say the light is *refracted.*

When an object which is under water is viewed from outside, the refraction of the rays results in making the water depth appear less, and a submerged object appears nearer the surface than it really is The student perhaps has met this case in early fishing expeditions, when the fish was invariably *not* in the place it appeared to occupy. The same effect is very noticeable in the bath. One's toes always appear to be near the surface, however prodigal one has been with the water supply.



REFRACTIVE INDEX. **Fig 1.** When light passes from air to a more dense medium such as water or glass, the refracted ray bends towards normal, making r less than i

By simple experiments the path of the rays from one medium to another can be traced out and the results agree with the following *laws of refraction* : (i) The incident ray, the normal at the point of incidence, and the refracted ray are all in the same plane ; (ii) there is always a constant relation between the sine of the angle of incidence and the sine of the angle of refraction for a given pair of media. The ratio $\frac{\sin i}{\sin r}$ = constant, which is called the refractive index (μ) for the pair of media.

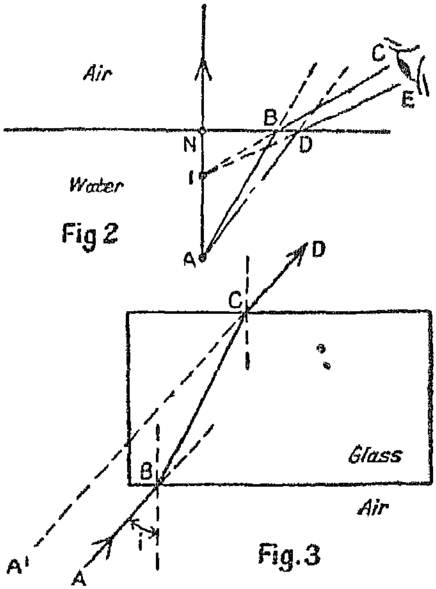
NOTE.—The sine of an angle is a convenient way of expressing the angle itself. For example, sin i (Fig. 1) = perpendicular AN ÷ hypotenuse OA ;

sine r (written sin r) = BM ÷ OB $\therefore \mu$ =

$$\frac{AN}{OA} \div \frac{BM}{OB} = \frac{AN}{BM}$$ and this is constant.

The refractive index is alway greater than unity when light goes from air to a more dense medium like water or glass, i.e. the ray from air always bends towards the normal, making *r* less than *i*, as in Fig. 1. If we reverse the path of the rays the refractive index is less than unity.

Now we might see why the object under water always appears nearer to the surface when viewed from air. Let A (Fig. 2) be such an object. The ray AN, from A at right angles to the surface, suffers no bending; any other ray is refracted as shown in the figure. The two rays drawn, AB and AD, are refracted along BC and DE respectively, and an eye placed to receive them is tricked into believing that the rays have come all along in the directions BC and DE—i.e. from I, which is the point where these rays meet if produced back. I is the image, and the object A appears to the eye to be at I, which is nearer the surface than A.



EFFECTS OF REFRACTION. Fig 2. An object under water seems to be nearer the surface than it really is. Fig. 3. Displacement of an object seen in a mirror.

If we have a slab of glass with parallel faces, the refraction results in a ray of light being displaced, but the direction is still parallel to its original direction. For example, if a ray AB strikes the face of such a parallel-faced glass slab (Fig. 3) it is bent towards the normal *in the glass*, as along BC, and away

along CD in air, where CD is parallel to AB. A appears to be at A^1

Prisms. If the glass is in the form of a prism we obtain a different result, which leads to rather important consequences. For example, in Fig. 4 we see the path of a ray ABCD, and notice that CD emerges in an entirely new direction. If the light AB is ordinary white light another additional fact is apparent. If we look in the direction DC we find that the beam which emerges is made up of the different colours of the rainbow. In other words, the incident white light AB becomes split up by the prism into these colours. We will return to this later; the simple deviation of the ray in the prism as a result of refraction at two surfaces is our present interest. If the angle of the prism, marked x in Fig. 4, is big, the deviation is big; if x becomes small, the deviation is small, as may be seen if different diagrams are drawn and a construction is used (as in Fig. 1) to find the path of the rays.

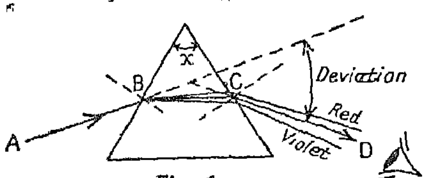


Fig. 4

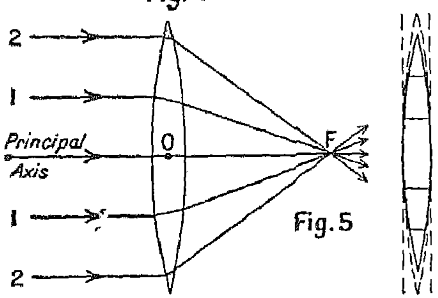


Fig. 5

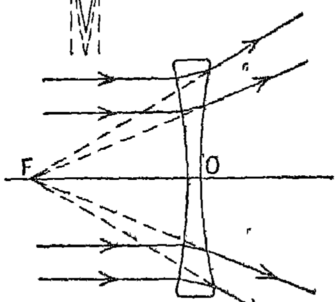


Fig. 6

REFRACTIVE DEVIATION. Figs. 4 to 6, illustrating the deviation of light rays in prisms and lenses.

In a lens we have the equivalent of several prisms of different angles placed on top of each other and the result is that rays falling on it are all bent to such an extent that they intersect and "are brought to a focus."

Take the case illustrated in Fig. 5, in which a parallel beam,

parallel to the principal axis, is incident on a *convex* lens. The ray along the principal axis, virtually, is striking a parallel-faced slab, and so goes through without deviation. Rays 1.1 each hit the lens at the same distance from the principal axis, and the part of the lens on which they fall may be regarded as prisms having an angle sufficient to make the rays pass through F Rays 2.2 fall on the lens where the equivalent prism has a larger angle, and produces so much extra deviation that the rays also pass through F after refraction. F is a *real* image, and the diagram illustrates what happens when a beam falls on the lens, producing a real image of the sun at F.

Although prism segments as shown in Fig. 5 would bring this about, a continuous surface such as that of a cylindrical lens is better; but in order to make the image symmetrical it is more often arranged that the lenses are spherical. The point F is called the principal focus and OF, written f, is the focal length.

Since the central part of the lens is really bounded by parallel surfaces, a ray of light which is directed to O passes through without deviation; it has a slight lateral movement (*see* Fig. 3), which is small if the lens is thin. Another form of lens is called the *concave* lens, and the action of this type of lens on a parallel beam is seen in Fig. 6. The rays only appear to come from F—they do not actually do so—and, therefore, F is a virtual image of a distant object.

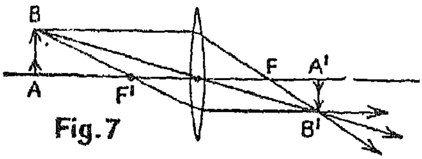
Images Produced by Lenses. That lenses are used in the camera, the projection lantern, the telescope and the microscope is well known, and it seems desirable to consider how simple lenses produce images, what arrangement of lenses is used in the instruments mentioned, and how this arrangement of lenses produces a final image.

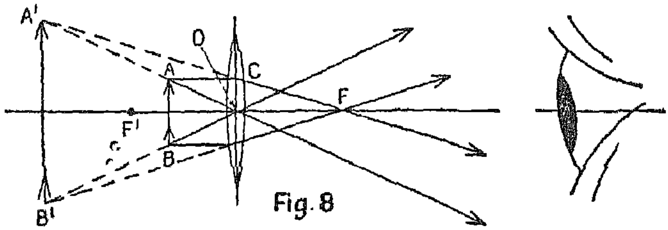
Considering, first, the simple lens, we find that we may obtain graphically the position of images produced, if we consider rays of light starting at one point on the object and find where they intersect after passing through the lens. If the rays do not intersect to produce a real image, they will appear to come from a point which is the virtual image of the object.

Three rays are sufficient, in general, to do this construction, as is shown in the case illustrated in Fig. 7: (a) a ray from B parallel to the principal axis, after refraction goes through the focal point, F; (b) a ray through F^1 after refraction goes out parallel to the principal axis, and (c) a ray through the centre

goes straight through the lens All these rays pass through B^1, which is the real image of B, and A^1B^1 is formed. So long as AB is farther away from the lens than F^1 there is a real image, which gets bigger and farther away as AB gets nearer F^1. The camera is in essence simply a lens or a group of lenses (Fig 7), which is moved along the line AA^1, so that the inverted real image falls on the ground glass screen or on the photographic plate at A^1B^1

When we use a convex lens of the kind shown in Fig. 7, as a "magnifying glass," we place the lens near the eye and then adjust the small object we wish to examine at a distance from the lens a little less than the focal length. This has the effect of producing a





PRODUCTION OF IMAGES BY LENSES Fig. 7, illustrating a simple lens, Fig. 8, showing how an enlarged image is produced (see text).

virtual image which is much enlarged. It is seen in Fig. 8 how this is produced. The rays appear to the eye to have come from A^1 and B^1, since they diverge after refraction. In principle, the astronomical telescope is a combination of the two cases. A lens of long focal length, called the object lens, is placed at one end of a tube which is pointed at the distant object, and a real image is produced in the tube Then a second lens of shorter focal length is used to view the image. The second lens is arranged as in Fig. 8, e.g. the real image is placed as AB and a virtual image of this, again magnified, is produced. There are many variations of this combination of lenses, which the student will find described in elementary books on light.

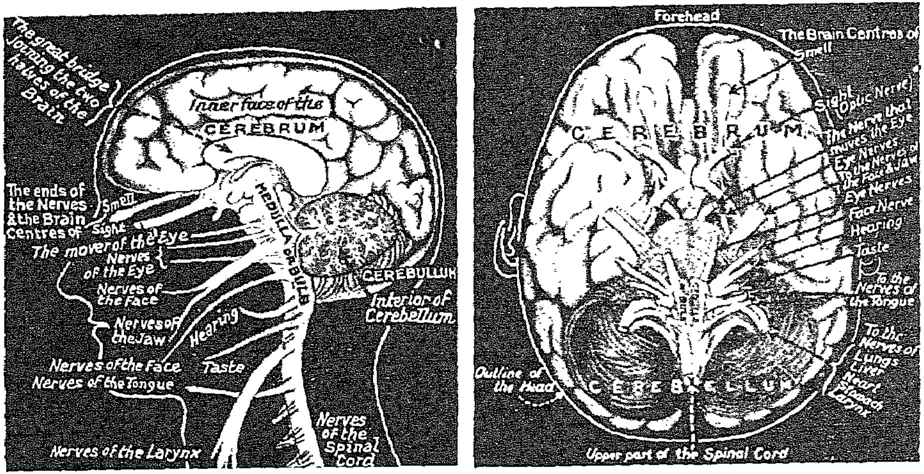
In the microscope, the small object to be viewed is well illuminated and the object glass, which is a lens of short focal

NAPOLEON AT TILSIT. After the defeat of the Russian and Prussian armies at Friedland (1807), the Czar Alexander I, abandoned his ally and came to terms with Napoleon. The two emperors met on a raft in the middle of the Niemen at Tilsit, and in this painting by Gioachino Serangeli we see Napoleon taking leave of Alexander. MODERN HISTORY 21

Musée de Versailles; photo, Neurdein

THE RETREAT FROM MOSCOW. Realizing the impossibility of carrying out his intention of wintering in Moscow, Napoleon began his retreat in October, 1812. Soon the Russian winter came to aid the Cossacks, and only a fragment of the Grand Army of half a million men managed to re-cross the Russian frontier. Atkinson's picture (above), published in 1813, conveys some faint idea of the appalling conditions under which the starving, frost-bitten troops encamped for the night. MODERN HISTORY 22

Aquatint by M. Dubourg, British Museum



SECTIONAL VIEWS OF THE BRAIN. Left, right half of the brain and the nerves which connect the medulla with the head and trunk. Right, the brain viewed from below, showing the relation between the three divisions and the origin of the principal nerves. PHYSIOLOGY 18

length, is placed at a distance from the object a little greater than the focal length. A real magnified image is produced a relatively long distance from the lens This real image is then viewed by the eye lens, which acts simply as a magnifying glass on the real image, and so produces a final virtual image, which is much magnified

The Spectrometer. We will conclude this very brief survey of refraction by describing the spectrometer, which incorporates most of the points we have discussed.

The instrument is used to produce spectra, which we will discuss in the next Lesson It consists of three parts: (i) a

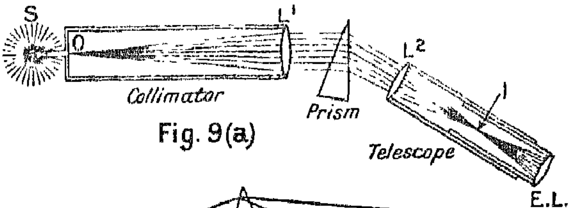


Fig. 9(a)

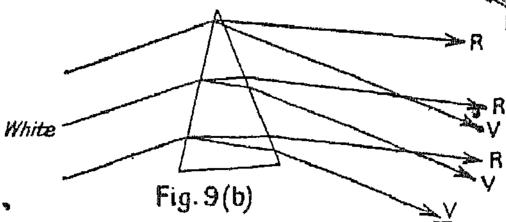


Fig. 9(b)

THE SPECTROMETER. Fig 9(a), component parts. **Fig 9(b),** *position of the extreme rays (red and violet) as bent by the prism.*

collimator, which is a tube having a slit O at one end, and a lens L^1 at the other. Since the slit is placed at the principal focus of the lens L^1, the light leaves as a parallel beam and falls on (ii) a *prism,* which is set to bend the light towards its base as already explained (*see* Fig. 5), and the light travels on as a parallel beam if it is of one colour, as seen in Fig. 9(a), and the third part (iii), the telescope, which is set in focus for distant vision, sees the image I of the slit as shown in Fig. 8 (the rays are left out in Fig. 9, for the sake of clearness) If a flame such as is given by a Bunsen burner or a gas ring heats a block of kitchen salt, the flame given is bright yellow If this is used at S, a yellow image is seen in the telescope If white light is used, the red portion goes as a parallel beam in one direction, and all the

colours of the rainbow each take their own path. The positions of the extreme rays are shown in Fig. 9b. The telescope focuses these parallel sets of rays as distinct images and the result is that one sees a spread of colour with red on the right continuously changing to violet at the extreme left (most deviated). The general impression of this band of colour, which is called a *spectrum* is seven main colour groups; red, orange, yellow, green, blue, indigo and violet. These colours are always in the same relative position, and in the next Lesson we will consider some of the many intensely interesting results which the study of such spectra yields to the experimenters in this branch of physics.

LESSON 16

The Composition of Light

LIGHT is transmitted as a transverse wave motion from the source to the receiver, as we have already stated. The fact is very well established as a result of many ingenious experiments, some of which are to be described in Lesson 17, where we shall see that it has been found possible to measure the length of the waves and obtain information as to the difference between the colours in this respect. Even the velocity of light has been found by special experiment. For many reasons it seems fairly certain that this velocity, which has the remarkably high value of 300,000,000 cms. per second (i.e. 186,000 miles per sec. or 669,600,000 miles per hour), is the highest speed attainable.

When we speak of the velocity of light, we must really be more specific and refer to the colour of light or refer to the velocity of light in empty space. We know, of course, that light can be transmitted through the tremendous distance between the distant stars and ourselves, that is, through a region in which no matter exists. The fact that this wave motion could be propagated through these empty regions led to the postulation of the ether. This purely hypothetical medium was, as has been said, invented "to supply the subject of the verb to undulate." Waves undulate or vibrate in something. In the cases known at the time of the commencement of the wave theory of light, as there was no material medium, an ether was postulated to give a more comfortable feeling to the theory. Once invented, its properties

were deduced and a large field of research commenced. At the moment we cannot follow this line any farther; our main concern is the vibration in it called light In empty space, light of all colours has the same velocity The colour of an extremely distant star is identical when viewed from the rise of the same to the going down thereof If one colour travelled faster than another that colour would tinge the first appearance of the star From experience, however, it is found that this is not so.

When light enters a material medium, it is slowed down appreciably. In some glass, the velocity of light of all colours is reduced to about $\frac{2}{3}$ of the velocity in free space, and in water it is about $\frac{3}{4}$ of the free space value Now, it is found that the different colours are not reduced in speed by *exactly* the same amount, although it is of the same order The violet light is most reduced, and the red least reduced in speed in all straightforward cases.

The ratio we have called the refractive index is found to be equal to the ratio of

$$\frac{\textit{the velocity of light in free space}}{\textit{,, \quad ,, \quad ,, \quad ,, \quad ,, the medium.}}$$

Now, as all the light has the same velocity in free space, it follows, since the refractive index of violet light is bigger than that of the red, that the velocity of the violet is less in any medium than that of the red in the same medium. All this has been confirmed by direct experiment.

We have seen that when the light from an incandescent solid falls on a prism, in the way described in Lesson 15, there is a continuous change in colour as we pass along the spectrum which is produced. Because of the nature of the colour scheme this is called a *continuous spectrum.* It simply implies that the source gives out a whole range of colours, which the prism separates.

Now, the velocity (c) is equal to the product of wave length (λ) and frequency (n), so that, for free space, we may calculate the frequency of each colour if we know λ and c.

This is constant for each colour, and is a much safer reference than an eye estimate of the actual colour itself When the light enters a medium, since the value of n is constant, λ changes within the medium. We have also learnt that the deviation in the prism depends on the colour and, therefore, we must now

associate the deviation with the more precise index, namely frequency.

For one prism, each frequency of light has its own deviation for a fixed angle of incidence. That is to say, the spectrum we see is a manifestation of a range of frequencies, which, when acting together, give the impression of white light.

Line Spectra. If we use as a source of light an electric arc which is struck between two rods of iron, we find that a continuous spectrum is not produced unless, by accident, we view the rods instead of the arc In place of the continuous spectrum we have a set of lines each of definite colour. It is just as though a selection has been made of certain colours or frequencies which is found to be absolutely characteristic of the particular source of light chosen. Always with an iron arc we have the same lines (or frequencies) separated by black spaces where no light exists. These lines are so definite that, if we had lots of unknown rods of metals and used them to produce a line spectrum, we could tell beyond a doubt which rods were iron by the spectrum produced. In this spectrum we have an infallible identification disk for the element.

Each element behaves in this way, i.e., each has its own line groupings. By careful use of the spectrum apparatus, an atlas showing the lines for each substance could be made, using photographs instead of visual identification, and this atlas would be a complete guide in an analysis of metals. If two metals are used, the spectra of the two would be superimposed and both could be recognized. This is the basis of a method of analysis by spectral means.

Band Spectra. Another characteristic form of spectrum is called the band spectrum. Here the lines are grouped together in the form of flutings or bands which are equally distinctive in analysis. More will be said of this when we discuss modern theories of atom and molecular structure, which can be supported by a study of the arrangement of the lines within the spectrum.

Absorption Spectra. When we discussed line spectra, an example of the line spectrum of iron was taken. This is really very complex. Perhaps the simplest common spectrum of this type is that given if a piece of common salt is placed in a Bunsen flame or on a gas ring. The flame looks yellow, and if analysed by means of a good spectrometer, it is found to be giving out two yellow lines in the visible region. These lines are very close together.

Now, if white light from an incandescent source is sent into the spectrometer, but on its way is made to pass through a cooler flame containing salt, it is found that the continuous spectrum has two vacant places which show up as black lines. These occur in just the place where yellow lines appeared when the "salt flame" was used as a source.

The spectrum is called the *absorption spectrum*, and the absent lines are just as reliable a guide to the cooler vapour contents as are the emission lines of the glowing sodium chloride flame itself.

One very interesting conclusion was made on these lines, from a study of the spectrum of the sun. If an image of the sun is focused on the slit of the spectrometer and a camera is made to take the place of the telescope, the photograph so formed is in general appearance very like that produced by an incandescent solid. Closer examination, however, shows that it is crossed by a large number of black lines, called "Fraunhöfer lines."

They are explained by the fact that the light from the sun comes from the incandescent core, which is surrounded by a cooler gas. The light passing through the sun's atmosphere is, therefore, robbed of certain frequencies, which are consequently absent when the light reaches the earth. Examination of these black "lines" led the physicist to a knowledge of the nature of these gases in the sun's atmosphere 93,000,000 miles away. Many well-known gases were identified. Some lines were still left over, and so new gases were discovered—at a considerable distance from the experimenters who found them. Helium has since been identified on the earth, and is now used in comparatively large quantities, but it was first found in the sun!

Invisible Radiations. When a continuous spectrum is produced and the frequency of the visible light waves is measured, it is found that the extreme visible violet has approximately double the frequency of the extreme red. Now, in sound, a note which has double the frequency of another is called the octave of that note. For this reason, we often refer, by analogy, to the "visible octave" when speaking of the spectrum. As a matter of fact, these waves which affect the retina and give the sensation of light are but a small fraction of the radiations which are emitted by a source. If a photograph is taken of the spectrum of, say, an iron arc or an ordinary carbon arc, it is found that lines are

produced well beyond the limit seen at the violet end of the visible region. These lines are said to be produced by the *ultra-violet* light. The ultra-violet light, whilst not affecting the retina, is very active in producing a photographic image. It has also the property of affecting the skin and producing the sun tan which we associate with the summer sun In winter, when the rays of the sun have to penetrate the longer air path in their oblique track to the earth, the ultra-violet light is largely cut off and, consequently, does not produce the same effect as in summer. From this it will be gathered that ultra-violet light is very easily absorbed. Ordinary window glass cuts off most of it, and it requires such substances as quartz or some of the well-known special glasses to allow a free passage for these rays. The ordinary sun spectacles cut out the ultra-violet rays, and it becomes clear from the circular patches of non-sunburnt skin round the eyes that the sun tan is produced by the short wave length, or higher frequency radiation. Many sources of light are rich in ultra-violet light, e.g. iron and tungsten arcs, glowing mercury lamps and the like, but in the latter case the mercury must be contained in a quartz container to allow the light to get out. In the same way we must use quartz prisms and lenses for our spectrometer in order to deviate and measure ultra-violet light.

Beyond the red an invisible long wave length radiation is given out. This is called *infra-red* radiation. This is very markedly strong in the heating effect it produces, and it is detected by sensitive heat recorders Like ultra-violet light it has medical uses, but, unlike the former, it can penetrate in its effects to a greater depth.

It will now be understood that the visible octave is only a small fraction of the energy sent out by a glowing solid. The "light" extends to many octaves and affects different senses. We shall see later that the wave motions here discussed are themselves only part of a very large family of similar radiations, which extend in wave length from several miles in length (wireless waves) down to one thousand millionth part of a centimetre (in radiation from radioactive bodies), and in all probability to a much more minute length in the recently discovered "cosmic rays" or penetrating radiation.

Our Course in Physics is continued in Volume 5.

LESSON 10

Ice and Snow as Nature's Sculptors

A MAP of the earth's ice covering (past and present), unless on a fairly large scale, could not show the distinction between the several Ice Ages of which we have evidence in various parts of the world ; it would probably display merely the extreme limits to which at any time the two great present-day ice-caps (Arctic and Antarctic) extended respectively south and north towards the equator, and the extent to which some ice-fields in other parts of the world exceeded their present dimensions. The general climatic changes which caused these successive advances and retreats of the ice covering were so widespread that not only the Alps, the Caucasus and the mountains of Central Asia, but even Mts. Ruwenzori, Kenya and Kilima-Njaro in equatorial Africa, as well as the southern Andes, all pushed their glaciers down to levels which today they are unable to reach. In South Africa and south-eastern Australia, too, we find evidence of former glaciation.

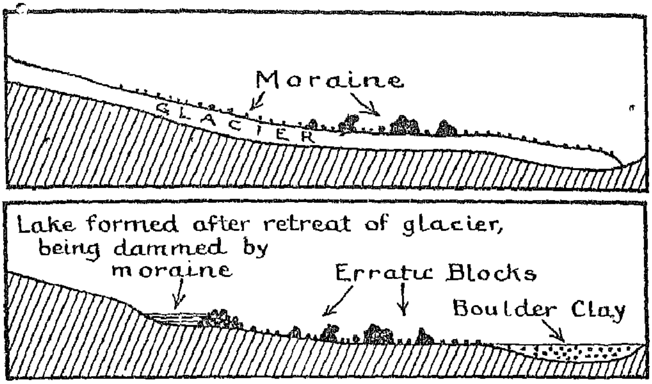
Prehistoric Glaciation. Evidence of this appears in several forms. For instance, rocks have been scratched or polished by the passing over them of long-vanished glaciers ; small fragments of rock, as in the so-called boulder clay, have been transported by glaciers, deposited when these retreated, and finally covered up by later sedimentary deposits ; larger fragments, when transported in this way and left stranded, are called erratic blocks (Fig. 2).

Pot-holes are formed by fragments of rock under a glacier to which the glacier, by its movement, imparts a rotary motion. This not only rounds and polishes the fragment itself, but also hollows out a circular hole in the valley-floor.

Ice-fields and Glaciers. The two great ice-fields of today are Greenland (825,000 square miles) and the Antarctic continent (5,000,000 square miles). About 85 per cent of Greenland's area is covered by an ice-cap of unknown thickness, formed by pressure of the overlying snow turning the lower layers into ice. This pressure has the further effect of setting up in the whole mass a downward and outward movement which manifests itself in

enormous glaciers, such as the 60-miles-wide Humboldt Glacier. The largest European ice-field is the Jostedalsbrae, in Norway, from which several glaciers descend to within 200 feet of sea-level—a lower level than is reached by any glacier not actually within one or other of the Polar circles.

The névé (snow-field) feeds the glacier, and is drained by it, just as a lake or swamp is drained by a river. When a glacier has



GLACIAL ACTION. Fig. 1. Sectional drawing showing a portion of the earth's surface covered by a glacier in the Ice Age. Fig. 2 (below). The same portion today, after the glacier has long since disappeared.

to descend more steeply over a ledge of rock, the ice is broken up by crevasses and forms an ice-fall or a sérac (a pointed mass or pinnacle of ice). As it moves down the valley, a glacier will collect on its surface débris that falls from the steep slopes on either side. These fragments form the moraines, called lateral or medial according as they are at the sides or in the middle of the glacier. Further débris is transported by the friction of the glacier along the valley-bottom, the whole being deposited at the foot of the glacier as an end-moraine from which issues the glacier stream formed by the melting of the glacier ice.

The rate of movement of glaciers varies considerably. In the Alps it averages from 50 to 200 feet a year. Movement is quickest at the surface and in the middle, being retarded by friction at the sides and along the bottom.

Origin of Icebergs. There are two ways in which Arctic icebergs are formed. A glacier, on reaching the sea, pushes on under water till the end of the glacier, buoyed up by the water,

breaks off and rises to the surface as an iceberg. Glaciers reaching a precipitous coast push their ends over the edge till they break off and fall into the sea. As might be expected from the rather violent manner of their formation the icebergs of the northern Atlantic, most of which come from Greenland, are often fantastic in shape. This is not so marked a feature in those of the southern ocean, because there the icebergs originate differently. Having a much smaller snowfall than the Arctic, the Antarctic continent has fewer glaciers. But the Great Ice Barrier, by which Captain Cook (1773) and Sir James Ross (1841) found their way south effectually barred, is a formation peculiar to the Antarctic. It is the breaking up of this barrier, or shelf-ice as it is called, which originates the southern icebergs, most of which are not so high as those of the north, though often greatly exceeding them in surface area.

Drift-Ice. This term includes not only icebergs, but also the floes into which the Arctic pack-ice and the Antarctic shelf-ice break up on the approach of summer. Its distribution is strongly influenced by the prevailing ocean currents. The effect of the Gulf Stream in preventing the drift-ice from reaching the British Isles is very marked, while the cold Baffin Bay current often carries it as far south along the Atlantic coast of North America as Cape Hatteras, in the latitude of Gibraltar. In the southern ocean the prevailing westerly winds prevent the drift-ice from travelling any great distance north.

Owing to the continual play of the currents the Arctic Ocean (except in the extreme north) is never completely frozen over, its ice covering consisting rather of cakes of ice (floes) which become smaller and less numerous as the summer advances.

The distribution of sea-ice in the northern portion of the Atlantic and Pacific is largely influenced by the prevailing westerly winds in those areas, with the result that the western coasts of North America and Eurasia are generally warmer than their eastern coasts. Thus the rivers and harbours of northern China, in the latitude of the Mediterranean, are largely ice-bound in winter, as is also the Gulf of St. Lawrence, in the latitude of the English Channel.

The freezing over of certain seas is of importance in connexion with world trade; it causes those necessary seasonal changes which are made in some of the great steamer routes. When Quebec becomes inaccessible by the freezing of the Gulf of

St. Lawrence, Halifax, which is ice-free, takes its place as Canada' chief port of entry. The line connecting Port Churchill, o Hudson Bay, with the Saskatchewan railways, for the direc export of the prairie wheat is, of course, useless in winter.

Lakes generally freeze from the surface—therefore much mo slowly when exposed to wind Of the great North Americ lakes, Lake Erie, the most southerly, freezes along the sho only; the others, usually all over

Rivers mostly freeze from below (ground-ice which rises to the surface). In western Europe rivers do not habitually freeze in winter, though they may frequently become blocked by accumulations of ice brought down from their upper reaches.

Snow does not play such an important part in physical geography as ice. For statistical purposes, it is usual to reckon a foot of snow as equal to an inch of rain. The length of time during which snow lies on the ground varies with latitude and elevation above sea-level, till the lower limit of permanent snow, the snow-line, is reached. The height of this line varies from sea-level in most parts of the polar regions to about 15,000 feet in the Himalayas and the tropical parts of South America and Africa. As regards Europe, the snow-line is at nearly 9,000 feet in the Pyrenees, about 7,000 feet in the Alps, and no more than 3,000 feet in Norway.

LESSON 11

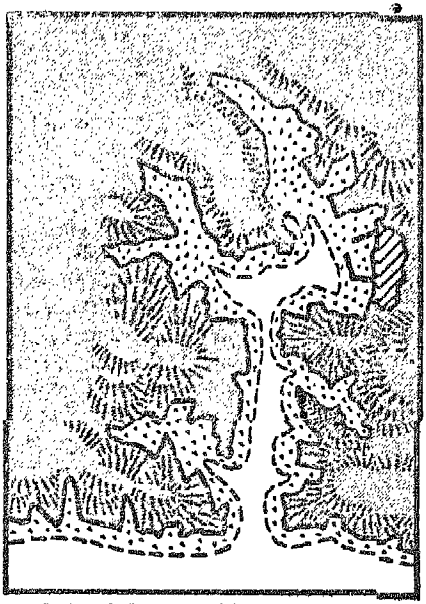
The Shaping of Shore Lines

We shall not expect a continent with so simple and uniform a table-land formation as that of Africa to have a very complicated outline. In western Europe, on the other hand, the long, much-indented shore line seems to be the natural result of a varied land-surface formation. The nature of the land along the coast will, however, be responsible for the main features only. For the working out of the details, we must look to two other factors: movements of the earth's crust and the action of the sea.

The effect on the shape of a shore line of the rising or sinking of the land is best illustrated by means of the sketch-map of a port on a rocky coast (*see* p. 555). At high tide—which is the same as saying that the land has sunk—there will be quite a

complicated outline of coast, with deep indentations. At low tide, when the land has risen, a level stretch of sand will be exposed, and the outline will be much simpler.

Bays formed by the sinking of land may be best described as "drowned valleys," and their shape will vary with the nature of the land along the coast. Thus Sydney harbour, Australia, reproduces in its outline the shape of a valley which descends from the east-coast range at right angles to the coast. Another type of drowned valley is San Francisco harbour. Its entrance known as the Golden Gate, represents a transverse valley through which the sea has gained admittance to form in the low-lying region behind the coast range, the actual bay. Where there are two or more parallel coast ranges, with transverse valleys, we get such coasts as that of southern Chile and British Columbia, where the sea has got in behind the outer range. This latter is now represented by strings of rocky islets, and the drowned valley by a narrow strait separating them from the real coast-line, now formed by what was the inner range.



SHORE LINE:
at High Tide ——
at Low Tide ----

A well-known form of drowned valley is to be found where glaciers have been at work. Here the result will be a long, narrow, steep-sided bay, which we call a fjord. It is generally shallow at its mouth, which is distinct evidence of its glacial origin, being due to the presence of a submerged end-moraine. The most remarkable instances of fjords are to be found in Norway,

other examples being the sea-lochs of western Scotland, as well as the narrow inlets of Labrador, Greenland and the South Island of New Zealand

Although not producing such striking coastal formations as those referred to, similar processes occur on low-lying coasts. The lagoons (limans) of the Russian Black Sea coast, although the rivers are gradually filling them with alluvial deposit, corresponded strictly, in their original shape, with the contours of the land. The estuaries of the Orwell and Stour are also good examples.

Where parallel mountain ranges run at right angles to the coast, we find them reproduced in the shape of long, narrow peninsulas, with narrow bays between them, as in Dingle Bay, Valentia Harbour, and elsewhere in south-western Ireland This "ria" formation, as it is called, takes its name from the similar type to be found in north-western Spain, where Vigo Bay and Corunna harbour are good examples.

The sinking of a low-lying sandy shore lined with sand dunes will result in the formation of shallow coastal lagoons, as in the "Landes" of south-western France. The valuable Bulgarian salt lagoons were probably formed in this way.

Where the land has risen the sea-floor will be exposed. If level, it will form a coastal plain with a very simple shore line. The southern shore of Hudson Bay is a good example of this, as is also the Atlantic shore, south of New York.

The action of the sea on the land along the shore line is of a twofold nature, destroying or building up. Coast erosion may take the form of a steep cliff-face being undermined by the sea, with the fallen fragments along its base, and sandy beach above low-water mark. Examples of this may be found at several places along the south coast of England, with its soft chalk cliffs. One of the most striking instances of erosion by the sea is Heligoland, which in A.D.800 had a coastline of 120 miles, reduced by 1900 to only 3 miles.

Low-lying coasts are often exposed to destructive sea erosion of a rather different nature. Storms which, in the case of a rocky coast, merely increase the eroding action of waves, become simply catastrophic when striking low-lying, and therefore defenceless, coasts or islands. Within historic times the Zuider Zee in Holland was a comparatively small inland lake many miles from the sea, while the East Frisian Islands were either not islands at all, or were close to the coast, and much larger than they are today.

Destroying at one place the sea may be building up elsewhere and in this latter work the play of the prevailing currents, or of the tide, takes a considerable part Familiar examples are Chesil Beach Dorsetshire which now joins the Isle of Portland to the mainland and the silting up of the Cinque Ports of Romney Rye, Winchelsea and Hythe

It is quite permissible to speak of several ages in the life of a shore line In its childhood a coast presents itself as formed under conditions due to the shape and undulations of the adjoining land In youth and middle age we find it with a varied and often broken outline due to unequal erosion of rocks of varying hardness In old age the promontories have been worn away to a certain extent while sand brought from elsewhere by current and tide has formed banks and spits across the mouth of inlets and estuaries which are also being filled up by débris and mud brought down by rivers and streams

LESSON 12

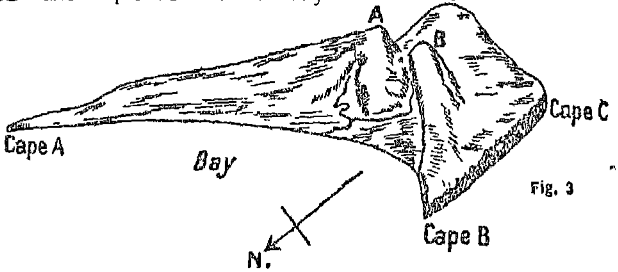
First Stage in Map-Making

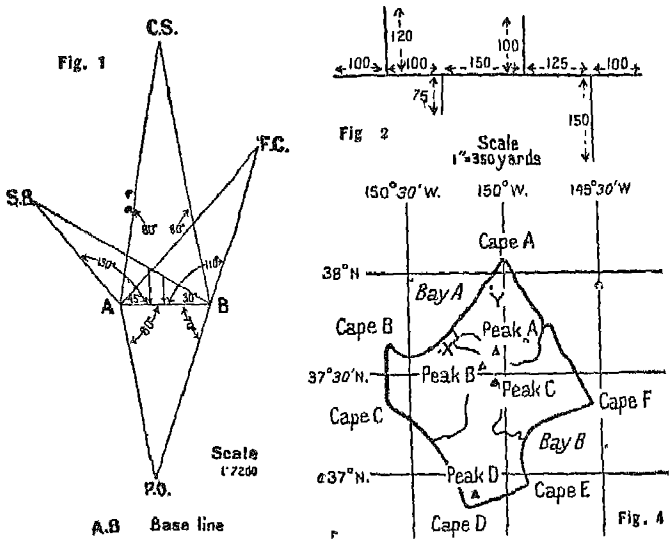
MAPS are at the same time highly useful and extraordinarily fascinating Titles to landed property and boundary rights ultimately depend upon maps Probably the most interesting piece of work achieved by a great explorer is the map he produces to illustrate his journeys The traveller sometimes finds considerable annoyance and at other times a rare delight, in the discovering that the official maps contain a mistake We have, here, to consider how maps are made, and it will be advisable to examine briefly the principles which are involved in the field work which precedes accurate map-making

The shape of a triangle depends entirely upon the sizes of two of the angles Triangles of the same shape have their sides in the same proportion, for example, if the side adjacent to the two specified angles in one triangle is a foot in length and the corresponding side in a second triangle of the same shape is two feet long the remaining sides of the smaller triangle are each half of the corresponding sides of the larger triangle

If we wish to make a map of the home surroundings we may proceed to use the above fact From a pole fixed in the garden

we measure the distance to a pole fixed in a neighbour's garden say, exactly 100 yards from our pole The line between the pole is the *base line*. From our pole we point a stick along the base line and swing the stick over a graduated circle placed horizontally





BASIC PRINCIPLES OF MAP-MAKING. Figs. 1 to 4 referring to experiments which are detailed in the text

until it points at the neighbouring church spire ; we then record from the circle " the angle of swing." Similarly, we measure the angle of swing when the stick is pointed to, say, the factory chimney, the school belfry, the telegraph post on the roof of the

post-office. From the second pole we measure in the same fashion the angles of swing to the same points, and we get the following record:

Angle of Swing.

	From our pole	From the second pole
To church spire	80	80
,, factory chimney	45	110
,, school belfry	130	30
,, post-office	80	70

NOTE.—The post office is on the opposite side of the base line from the other buildings

We now proceed to make the map. On a scale of 1 in 600, 100 yards is represented by 6 inches. Draw a straight line 6 inches long, plot the angles specified above, and extend the lines until they meet. The result is similar to Fig. 1, which is drawn on a scale of 1 in 7,200, or 1 inch = 200 yards. Having drawn the map, we can use it to discover the distance from one of the six points to any of the others. Since it is necessary to draw a triangle for each point sighted from the ends of the base line, the principle here illustrated is called *triangulation.*

The instruments which are used for triangulation all depend upon the measurement of angles.

A prismatic compass gives the bearings of each line of sight, and from these the angle of swing is calculated. To facilitate sighting, metal pieces with slits and wires are attached to the compass.

A *theodolite* consists of a telescope for sighting purposes, specially where the distances are great, and two graduated circles, one horizontal and one vertical, on which are read the angles of swing and tilt respectively of each object sighted.

It is sometimes desirable to get the triangulation drawn as the sighting is performed. This method obviates the reading of angles in degrees and fractions of a degree, and yields a map drawn out of doors The instrument for this purpose is a *plane-table*, of which the essential parts are a horizontal drawing-board and a sighting ruler—i e. a ruler fitted with metal uprights as in the prismatic compass, to ensure accuracy.

In every case, however, the length of the base line is measured. For this purpose a *surveyor's chain* is usually used. A second principle of surveying is embodied in the method of *off-sets*,

illustrated in Fig 2. This method can be carried out with a chain and a cross-staff, but it can only be used when the surveyor actually goes to the points at the ends of each of the off-sets.

Such a necessity limits the usefulness of the method, because it confines it to small areas which are free from obstructions on the ground. The *cross-staff* is an instrument by which the surveyor is able to make sure that each off-set is at right angles to the base line.

The way in which these survey methods are used for map-making may be illustrated by the following proposition:

"A commercial air route is under plan across an extent of ocean. An aerodrome with landing and repairing facilities is required about half-way across The island, Mañana, promises a suitable site, but there are no good maps of the island A party of surveyors is sent to make the desired map as a basis for the purchase or lease of the whole or part of the island"

The surveyors approach the island from the north-west, and see the view shown in Fig 3. They proceed to determine the latitude and longitude of the three Capes, A, B, and C.

A boat party is landed at Cape A about 11.30 a.m. The angular elevation of the sun above the horizon at the precise moment when the sun is highest in the sky is measured with a sextant: the value obtained is 62° 15′ 30″. The time registered by a chronometer which keeps Greenwich time at the moment of the sun's maximum altitude is 10 p m The surveyor proceeds to make the following calculation. The sun's altitude at local noon at Cape A is 62° 15′ 30″—i.e. the sun's distance from the zenith is 90°—62° 15′ 30″, 27° 44′ 30″. Therefore 27° 44′ 30″ is the difference between the latitude of Cape A and the latitude of places where the sun is exactly overhead on this day.

The "Nautical Almanac" states that on this day the sun is overhead at lat. 10° 19′ 30″ N. Then the latitude of Cape A is 27° 44′ 30″ + 10° 19′ 30″ N—i.e. 38° 4′ 0″ N

Because the Greenwich time of local noon is 10 p m., Cape A is $\frac{10}{24}$ of 360° west of Greenwich, i.e 150° west longitude.

By circumnavigating the island and landing boat parties at the several capes the explorers are able to make sketches of the coast views and to determine the latitude and longitude of the chief capes. From their observations a *first* map is made, Fig. 4, on which the positions of the Capes A to F are accurately fixed, and all the other information is merely sketched in.

Fig. 4 is merely a diagrammatic map made within a square of which the sides represent one degree of longitude or one degree of latitude. One degree of latitude is always the same length, 60 nautical or geographical miles and nearly 70 English or statute miles, but one degree of longitude may be merely one statute mile, if it is measured from east to west near the North Pole, or nearly 70 statute miles, if measured along the equator; consequently, Fig. 4 distorts the shape of the island by making it appear broader than it really is. This distortion is not a matter of great importance in a diagram such as this.

LESSON 13

Triangulation in Map-Making

In the preceding Lesson we supposed that a boat party had landed on the island of Mañana to make a survey and map, with a view to ascertaining whether the island would be suited for an aeroplane base. Having pitched their camp near the mouth of the stream on the shores of Bay B, on the first clear night the surveyors proceed to check the latitude of Cape F by measurement of the altitude above the horizon of the Pole Star (the latitude of a place is always equal to the altitude of the Pole Star above the horizon measured at that place), which is found to be 37° 21′ 0″. Meanwhile, a wireless installation at the camp put them into rapid touch with the rest of the world, and the longitude is checked by exchanging messages with the nearest observatory.

The surveyors tramp about on the island to find the largest possible stretch of level ground. They decide on the line X Y along the shores of Bay A, and proceed to measure the length of X Y as accurately as possible; it is found to be 40 miles. *The line X Y is the base line for the primary triangulation of the island which is next determined*

The First Triangle. Theodolites are erected at X and Y, and the angles to Cape B from these places are determined (Fig. 1). Angle *a* is 120° and *b* is 30°. From the known length of X Y and the angles 120° and 30° the distances of Cape B from X and Y are calculated.

The Second Triangle. The angles from X and Y to Peak A are measured; first the angles of swing, *c* and *d*, and then the angles of tilt above the horizontal, *e* and *f*. The air triangle, X Y Peak A, will appear on a map as the triangle X Y M, and from the known length of X Y and the angles of swing, *c* and *d*, the lengths of M Y and M X are calculated Using the length M X, and the angle of tilt *f*, the height of Peak A is calculated. By using the length M Y and the angle of tilt *e*, the height of Peak A is determined again, and this last calculation serves to check the whole piece of work.

Up to the present the horizontal base line is used to determine the horizontal first triangles, X Y Cape B and X Y Cape A; and also to determine the positions and heights of Peaks A and B, both of which are visible from X and from Y. But Peak C is not visible from Y, so the line M X and the angle of tilt *f*,

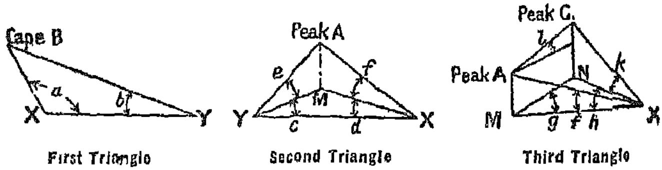


FIG. 1. TYPES OF TRIANGULATION

which have already been determined, are used in the third triangle.

The Third Triangle. It is usual to mark the precise points sighted with the theodolite by flagstaffs or cairns, so that the theodolite is transferred from Y to the cairn on Peak A, and the angle of swing *g* and that of tilt *l* are measured, while the angles of swing and tilt, *h* and *k* respectively, are measured from X. From these observations the lengths of M N and N X and the height of Peak C are calculated.

By using the line from Peak A to Peak C a third triangle is used to fix the position of a cairn erected on the top of the cliff at Cape C, and from this cairn and Peak C the position and height of Peak D are fixed.

In this fashion the whole of the island is covered by a network of primary triangles, of which the first few triangles are shown diagrammatically in Fig. 2. This method of map-making depends upon the principle of *triangulation*.

The surveyors have now reached a stage when they know the island fairly well and they decide that there are two possible sites for the aerodrome one near the shore west of Cape F and the other on a plateau north east of Peak D Consequently the whole area of the triangle C D Cape F (Fig 2) is more accurately surveyed by a series of smaller secondary triangles with the result that (i) the coastline of Bay B, (ii) the course of the river which enters the bay (iii) the situation of the ridges which radiate from Peak C, (iv) the steep edge of the southern plateau, (v) possible railway routes from a settlement near the mouth of the river to each of the aerodrome sites, are all accurately fixed upon a map, as seen in the diagram in the following page

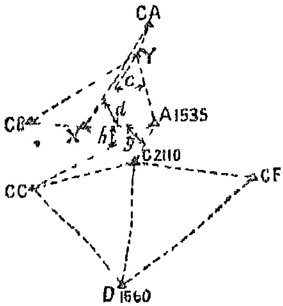


Fig. 2. Parts of the primary triangulation

Three other pieces of work remain to be done (a) the survey of the course of the main rivers in connexion with the possible water supply for the town settlement and the aerodrome, and in order to determine the best sites for farm settlements (b) a still more detailed survey of the immediate neighbourhood of the aerodrome sites and (c) a fairly elaborate and detailed survey of the site for the proposed town settlement and for harbour works

A rapid survey of the main river valleys is carried through with (i) an aneroid barometer (ii) a plane-table, and (iii) a prismatic compass The surveyor reaches the river and fixes the location of a prominent landmark on the bank, chosen for its convenience, by taking compass bearings from two or more of the cairns used in the primary triangulation, he proceeds along the river and draws on the plane table lines of sight to landmarks on the river bank and to the cairns At each landmark he determines his height above sea level by means of the aneroid

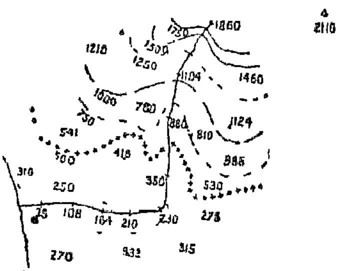


Fig. 3 Diagram showing how contours are drawn from spot heights

As a result of the plane-table work a series of sketch maps is made on which "spot-heights" are marked, as in Fig. 3. The surveyor who actually traversed the area uses these spot-heights to sketch in contours or height-lines, as shown in Fig. 3

Such sketchy contours are not sufficiently accurate for use regarding the rival merits of the two possible aerodrome sites, so that the surveyors, equipped with chains, surveyors' poles, and theodolites, proceed to make detailed surveys of the flat, almost level areas which they have selected. On these surveys the contours are shown for every 25 feet; and the parts of the sketch contours, which occur in the neighbourhood of each area, are carefully corrected. Finally, with chain and theodolite a plan of the proposed town settlement is "pegged out" on garden city lines, and a map of the settlement constructed to show the proposed streets, etc. The final results of the survey comprise a map of Mañana, such as Fig. 4, and large scale plans of the two aerodrome sites and the town site.

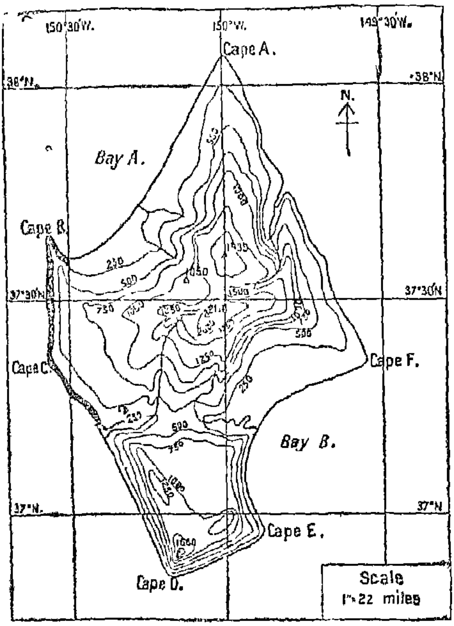


FIG. 4 Contoured map of Mañana

This Lesson concludes our Course in Physiography.

LESSON 16

The Hormones and Their Functions

In Lesson 15 (Volume 3, page 613) we reviewed the nutritive fluid of the body as the medium on whose constant composition depend the life and health of the cells, as individual units. Cells are united to form tissues, tissues to form organs, organs to form systems—each group of cells, tissues and organs being specialized to perform definite functions.

This division of labour and office is the product of evolution, and becomes ever more complex as life proceeds from more primitive to more highly organized forms. Comparison with the development of a fighting force may be helpful. Such a force may consist of anything from a small band of individuals, acting more or less in concert, to a highly organized modern army corps, with its divisions, brigades, companies and platoons, its service corps, medical corps, intelligence service, etc.—a vast organization requiring a controlling centre, general headquarters, in control of and in communication with every department. Each department has also its own control over and communications with its own and every system of units. In this manner complete co-ordination and unified action are secured, so that the whole acts as a single machine. Means of communication may be by human runners or by field telegraphs radiating from headquarters.

In living organisms of a simple kind, communication and control are effected solely by a postal system in which chemical substances manufactured in specialized parts of the organism are conveyed by a primitive form of circulation to other parts, the activities of which are thereby influenced. Higher in the scale of life, a simple form of nervous system appears. This consists of highly specialized cells linked together by communicating fibres and grouped into nerve centres, each cell giving off a long fibre or nerve filament, which conveys impulses generated in the nerve cell to some other part of the organism. Other nerve cells receive messages arising from stimuli brought to bear on the peripheral parts, which serve to keep the organism in touch with its environment, and enable it to provide the suitable

response. This primitive nervous system develops in close association with the groups of cells from which the chemical messengers are derived—Nature is conservative and makes use of her more primitive methods to build up her higher organizations. Much of the control and regulation of the various systems continues to be effected through the medium of the special cells which provide the chemical messengers, or, as they are more commonly termed, the hormones

Higher in the scale of life the nervous system is divided into two more or less distinct but closely interrelated parts (1) the more primitive vegetative or, as it is sometimes called, autonomic or sympathetic system, and (2) a central nervous system consisting of brain and spinal cord in communication with all parts of the organism through wide ramifications of nerve fibres. They form a great central nerve exchange, in which all messages from the outer world are received and from which all messages giving rise to muscular activity are sent out. Co-ordination and control of the bodily systems are delegated to the vegetative nerve cells and fibres and to the hormone-producing cells These, while carrying on automatic and unconscious control of the vital processes, are, nevertheless, linked up closely with the higher centres in the central nervous system and are constantly under their influence, with the result that every system—circulatory, respiratory, digestive, etc—is brought into immediate touch with, and is able to respond to, every stimulus received from the outer world, and to adapt itself to meet every call received by every other department of the body

No longer concerned with the routine regulation of the vital organs, the brain in the higher forms of life has developed a more advanced form of nervous activity, and special parts of it have been set aside to serve as the seat of consciousness, of the intellectual activities—the capacity to reason and to control to a large extent the external environment, and so to spare the work thrown on the more vital mechanisms. These highest functions, however, remain in close touch with everything that is happening. They can mobilize the activity of every department and, in their turn, are influenced by any bodily disorder

Glands of Internal Secretion. Our immediate concern is with the hormones Secretin, the hormone elaborated by cells in the wall of the duodenum in response to the stimulus of the acid contents of the stomach in contact with them, is one

example, and insulin, secreted by special cells in the pancreas, is another. Secretin is posted by way of the circulation to reach the pancreas, where it stimulates the cells of that organ which secrete the pancreatic juice. Hormones have, in every case, a special destination and a highly selective action. They originate in certain glandular organs of a special kind.

Glands are of various orders. Lymphatic glands are part of the lymphatic system, whose office it is to cleanse the body of microbic invaders. Other glands secrete juices which pass to their destination by way of a duct or tube; such are the salivary glands, liver and pancreas. Hormones are derived from glands that have no ducts, but which pour their secretion direct into the capillary blood vessels that surround their cells; hence they are known as the ductless glands or glands of internal secretion. The liver and pancreas resemble them to some extent inasmuch as, in addition to their digestive juices which are secreted through ducts, they make hormones which pass direct into the circulation. The glands of internal secretion are as follow: (1) The adrenal or suprarenal glands, each of the size of a lith or segment of an orange and lying just above each kidney. They are richly supplied with blood vessels and with nerves connecting them with the sympathetic nervous system. (2) The thyroid gland. This is the largest ductless gland and is situated in front of the neck, where it lies astride the windpipe; it is also highly vascular and intimately connected with the autonomic nerves. (3) The pituitary gland. This is about the size of a cherry and is situated within the cavity of the skull resting on its floor at the base of the brain. (4) The genital glands, the ovaries and testes. These, in addition to their reproductive function, secrete hormones of great importance to the growth and activity of the organism. (5) The pineal gland, a tiny structure buried in the brain.

LESSON 17

Further Study of the Hormones

In continuing our study of the glands whose office it is to provide the hormones, or chemical messengers, we shall see that in these small but very active organs hormones of two kinds are prepared. Some are intended for, and produce immediate effects in, the controlling and exciting of the action

of specific parts of the bodily machinery. Others, while they produce no immediate effect, have to do with the growth and upbuilding of specific tissues. That is to say, some hormones are concerned with function and others with maintenance and development.

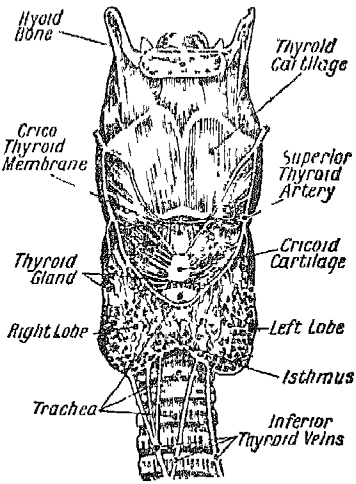
Of the first mentioned, the substance adrenalin, produced by the suprarenal glands, is a typical example. When we were studying the circulation of the blood, we saw that the stopcock action which controlled the supply of blood to various parts was partly brought about by the action of this substance. This action comes into play whenever sudden, prolonged or violent muscular activity is called for. It is essentially an emergency provision.

A sudden and alarming situation may have to be met by fight or by flight, or a violent emotional disturbance call up a primitive instinct, such as anger. Going into action under shell-fire, with not only its call on the muscular system but also its associated fear and excitement, would, for instance, make a great demand on these glands. The call for action is received by the brain; messages hence flash out by way of the sympathetic nervous system to the adrenal glands, and these respond by putting out a rapid increase of secretion into the blood stream. *Immediately, in certain areas of the body, especially in the* alimentary tract, the blood supply is shut off so as to meet only the barest possible requirements of the organs concerned, while the supply to other parts, whose activity is needed to the fullest extent—such as the heart, lungs and voluntary muscles—is increased to a maximum.

In normal circumstances, the varying needs of the organs for blood are met by the control of the sympathetic nervous system. Adrenalin provides the extra stimulus to meet an emergency demand. This secretion has also another helpful mode of action under these circumstances. It stimulates the liver cells which store glycogen to pour glucose into the blood stream, and so provide for the increased demands of the muscles for fuel. Adrenalin is especially interesting in that it is the only hormone substance that has as yet been prepared by the chemist in the laboratory In vivo, it is made by the cells constituting the central part, or medulla, of the gland; the outer part or cortex secretes a hormone, the action of which is concerned with development and maintenance, especially those of the sex organs,

and it also appears to promote the resistance of the body to toxic agents The cortical secretion is indeed more essential to daily life than that of the medulla, though the action of the latter is better understood, and forms an instructive picture of the mechanisms which link up mind and body, of which as yet so little is known

Thyroid Gland. The thyroid gland, the secretion of which is composed very largely of iodine, has both a functional and developmental activity It shares with the adrenal glands the preparation of the body to meet sudden and excessive demands on muscular activity and emotional disturbances When such calls are made on it, it becomes more active, and the hormone it secretes has the effect of increasing the hunger of the tissues for oxygen The fires of life blaze up, and combustion occurs at a greatly increased rate In this way it reinforces the action of adrenalin Thyroid secretion also plays a highly important part in the development and maintenance of mind and body A child whose thyroid gland is defective in function is stunted in mental and bodily development, and, unless given thyroid gland substance obtained from an animal, becomes a cretinous idiot Adults with defective thyroid secretion are subnormal in both mental and bodily activity Their fires of life burn sluggishly, and the activity of all the rest of the internal secreting glands is impaired If, on the other hand, the gland is overactive, as sometimes happens, the individual is restless, excitable and emotional, with rapid pulse and bodily wasting from excessive combustion Where secretion is defective the sexual activities are markedly diminished, owing to the close connexion between the sex glands and the thyroid.



THYROID GLAND. Important two-lobed ductless gland lying in front of the trachea.

Pituitary Gland. The pituitary gland is essentially a growth and-development controlling organ Its principal hormone controls all the systems of the body concerned with muscular work and enables them to respond to the demands made on them In certain abnormal cases the gland is overgrown, and this leads to excessive tallness of stature, or, in some cases, to abnormal development of certain bones and muscles—a condition known as acromegaly In health the secretion is responsible for the strengthening and better development of bone and muscle that normally follows on muscular exercise, as, for instance, in the case of the brawny arm of the blacksmith The over-development which occurs in the abnormal cases referred to is soon followed by degeneration Nature has, as so often, overshot the mark Another hormone secreted by the pituitary is now known to control the changes that occur in the ripening of the female germinal cells

Lastly we have the sex glands These, in addition to their reproductive function, secrete a hormone which has a powerful action on growth and development It acts indirectly through the media of the glands we have been considering by stimulating their activity All these glands take part in team work, and failure on the part of one involves all the others In the absence of or with defect of the sex glands the anatomical features which denote the male or female fail to develop Bodily contour, growth of hair in certain parts, tone of voice and external sexual structure are so altered that determination of sex by ordinary observation is difficult or impossible Excessive production of the sex hormone leads to premature sexuality, often at a very early age, with too early development of the anatomical sex organs and characteristics—voice, hair, bodily contour, etc

Space will not permit of reference to the less important internal secreting glands Though inferior members of the team, yet they play their part, under the supreme control of the central nervous system, in determining the bodily and mental characteristics of the race and of the individual, in creating "personality" and in controlling function A little more or less of one or other hormone, and all those characters which distinguish the behaviour, personal appearance and temperament of the individual may undergo complete transformation.

LESSON 18

Structure of the Human Brain

(See plate 62)

THE mechanism through which the body responds to, controls, and is in conscious touch with its environment, consists of a central nerve machine, from which radiates to all parts of the body a system of living wires, the nerves Supreme in the make up of the central machine is the brain. As a great administrative and governing organ, it is the seat whence issue all impulses to voluntary movement. To it pass messages from the outside world to be recorded in consciousness, and it is the seat of the intellectual processes built up from sensory impressions, thought, memory, reasoning, emotion, and the will. The brain occupies the greater part of the cavity of the skull, the rest of the available space being occupied by its three layers of membranous coverings or meninges, the space between the outer layers being filled with the cerebro-spinal fluid. This fluid not only bathes the outer surface of the brain and spinal cord, but is found in hollow cavities or ventricles within the brain, and also in the central canal of the spinal cord. It acts as a kind of water cushion for the delicate structures it surrounds. A vast field of capillary blood vessels permeates the brain tissue fed by the large carotid arteries, which leave the aorta soon after its origin from the heart, while the return of venous blood takes place through large venous spaces or sinuses lying on the inner surface of the cavity of the skull.

The brain has a complicated structure. It is divided into an upper and lower portion partially separated by a horizontal membrane extending across the skull cavity. Above the membrane lies the largest portion, the cerebrum. This is divided by a vertical fissure into right and left cerebral hemispheres, united across the fissure by a broad band of brain tissue composed of bundles of nerve fibres, the corpus callosum. Below the horizontal membrane the brain stem or mid-brain extends down from the centre of the cerebrum. This stem, in turn, merges below into a rounded mass, the *Pons Varolii* or bridge. Lying behind the bridge is a larger mass having two lobes and a striated appearance of its surface. This is the cerebellum or small brain. Below

this level the bridge passes into the enlarged upper end of the spinal cord, the bulb or medulla oblongata Where this merges into the spinal cord the latter passes through the hole in the base of the skull the foramen magnum, into the spinal column The pons or bridge serves to connect up the bulb with the upper brain, and the cerebellum with the rest of the nervous system In the bulb are situated the vital nerve centres which govern the action of the heart, lungs and digestive tract

Grey Brain Substance. The substance of the brain is of two kinds—a white substance, most of which consists of bundles of nerve fibres and a smaller amount of grey substance A layer of the grey matter covers the surface of the brain, and it is also found in isolated masses in the lower part of the cerebrum and cerebellum This grey matter is composed of nerve cells with branching processes which form a dense network The layer of grey matter on the surface of the brain is known as the cortex Here the cells are arranged in layers of varying depth In some parts they are 20 and more deep the cortex being nearly a quarter of an inch in thickness From each cortical cell runs a main nerve fibre or axis cylinder, these are collected into bundles to make up the mass of the interior of the cerebral hemispheres Other shorter processes from the cells branch, intermingle and come into close contact with similar processes from other cells These processes are known as the dendrites, and through them the cells are enabled to be in communication with one another The extent of the cortex is greatly increased by being disposed in folds or convolutions, separated by fissures or sulci of varying depth Some of these fissures separate the surface of the cerebrum into more or less distinct areas, and within each of these areas the cortical cells perform special functions in their capacity as the highest class of nerve operatives Thus an area at the hinder end of the cerebral hemisphere subserves the function of vision Objects on one side of the middle line of the body are here visualized, but on the opposite side of the brain

Motor Area. More anterior is an area—the motor area—the cells of which imitate voluntary muscular action This area is divided up into smaller areas, each of which controls the movements of certain sets of muscles Thus there is a centre for the arm, another for the leg, another for the face, and so on The nerve fibres passing from these cells and conducting their message cross over the middle line at some lower part of th

central machine so that the limbs and face on one side are controlled by a motor centre on the other side. Hence an injury to one side of the brain will cause paralysis on the opposite side of the body. An area situated below the motor region subserves the reception and recording of sound waves—the auditory centre. Close to it, again, is the speech centre. In the cortex of the frontal lobes of the hemispheres are the cells responsible for the highest intellectual processes.

The complexity of the cortical convolutions is an index of intelligence and mental activity. As we ascend the evolutionary scale so we find an increasing development not only of the size of the brain, but in the thickness and surface extent of the cortex. For every new attainment and train of thought achieved by the species, new groups of cells and ramifying dendrites are required. These become linked up and form a beaten path, as it were, for oft-repeated messages to pass along. Thus mental habits and habitual muscular movements are formed and established. The masses of grey matter lying at the base of the cerebrum and composed of nerve cells and their processes are believed to be the centres where the highest forms of sensation are recorded, thence to be transferred by nerve channels to the higher centres in the frontal lobes. Such sensory experiences are feelings of pleasure and pain, comfort or discomfort. These centres may, therefore, be regarded as the seat of the emotions, and we find that they are linked up with the automatic or vegetative nervous system through which nerve impulses are conveyed from them to the circulatory and digestive and respiratory organs.

Composition of the Spinal Cord. The spinal cord is the great main cable through which the administrative centres of the brain are in communication with the body. It is divided into two columns connected by a continuous bridge work. Unlike the brain, grey matter forms the core of the cord and the white matter surrounds it. In the grey matter are groups of cell operatives, while the white matter consists of nerve cables uniting the cells of one station with those of a distant one. The grey matter and nerve fibres of one column are connected up with those of the other column by fibres passing across the connecting bridge. The spinal cord represents the primitive nervous system. Only in the higher forms of life is the grey cortex found on the surface of the brain, thus allowing for its higher development.

Our Course in Physiology is continued in Volume 5.

SPANISH

LESSON 1

Why We Should Learn Spanish

A KNOWLEDGE of the Spanish language is of growing importance in the commercial world today, and many business men, indeed, consider Spanish more desirable than German, perhaps because so many Germans have a knowledge of English. During the past few years the use of Spanish has spread considerably, and with the rapid development of the resources of South America, where Spanish is the language of business, a working knowledge of the language should become an excellent investment in a business career even if there were no other advantage to be gained. But, of course, there is. We emphasize the commercial value of Spanish, but it must not be overlooked that Spain has a modern literature which, if often wanting in originality, has many works, both grave and gay, of distinct talent.

To the student with some knowledge of Latin, the study of Spanish should come more as a pleasure than a task, for he will find many words which have a familiarity about them, and the pronunciation will present little difficulty. A phonetic pronunciation is given in the early chapters of this Course, and the student should follow it carefully, noting the slight differences of pronunciation between the Spanish of Castile and that of South America.

The Alphabet. The Spanish alphabet is composed of twenty-nine letters. There are twenty-four consonants, whose names are pronounced as follow:

B	.. bay	K	.. kah	R	.. a-ray
C	.. thay	L	.. el-lay	RR	.. ar-ray
CH	.. chay	LL	.. el-lyay	S	.. essay
D	.. day	M	.. em-ay	T	.. tay
F	.. ef-fay	N	.. en-ay	V	.. vay
G	.. hay	Ñ	.. en-nyay	X	.. a-keess
H	.. ah-chay	P	.. pay	Y	.. e-gree-ay-gah
J	.. hoh-tah	Q	.. koo	Z	.. thay-tah

Pronunciation. There are five vowels, and the distinct sound of each, which is the same as its name, is never varied. The

vowels are pronounced as follow:

A	E	I	O	U
ah	ay	ee	oh	oo

The *u* is silent in the syllables *que, qui, gue, gui,* which must be pronounced *kay, kee, gay, gee*; when the *u* is to be pronounced in syllables of this kind it is marked thus *ü*. Y is occasionally used as a vowel, and then it sounds exactly the same as the Spanish *i*.

B sounds softer than in English: *bota* (boh-tah), boot; *banco* (ban-koh), bank.

C sounds like *th* in English, before *e* and *i*—*cena* (thay-nah), supper; *cinta* (theen-tah), ribbon. It is pronounced hard in front of *a, o, u,* or any consonant: *casa* (kah-ssah), house; *coco* (koh-koh), cocoa-nut; *Cuba* (koo-bah), Cuba; *clero* (klay-roh), clergy; *cronica* (kroh-nee-kah), chronicle; *acceso* (ac-thay-ssoh), access.

D and F sound as in English—*dia* (dee-ah), day; *fuera* (foo-ay-rah), outside.

G before *a, o, u,* or any consonant, is pronounced as in the English word *good*—*ganar* (gah-nahr), to win; *goma* (goh-mah), gum; *alguno* (ahl-goo-noh), somebody. Before *e* or *i*, it has a trilling guttural sound, somewhat like a strong English *h*—*género* (hay-nay-roh), merchandise.

H is always silent—*hora* (oh-rah), hour; *hablar* (ah-blahr), to speak.

CH sounds invariably as in the English word *chair*—*chocolate* (choh-koh-lah-tay), chocolate.

J sounds like the Spanish *g* before *e* or *i*—*jornales* (hor-nah-layss), wages; *judio* (hoo-dee-oh), Jew.

K sounds as in English—*kiosko* (kee-oss-koh), kiosk.

L sounds as in English—*labio* (lah-bee-oh), lip.

LL sounds somewhat similar to the syllable *li* in the English word *pavilion*—*lleno* (lyay-noh), full; *calle* (kah-lyay), street.

M and N are sounded as in English—*mesa* (may-sah), table; *nunca* (noon-kah), never.

Ñ sounds somewhat like *ni* in the English words *onion* and *pinion*—*compañia* (kom-pah-ni-a), company; *sueño* (soo-ay-ni-oh), sleep.

P and Q are pronounced as in English—*presidente* (pray-see-dayn-tay), president; *querido* (kay-ree-doh), dear.

R is pronounced as in English, in the middle of a word, unless

immediately preceded by *l*, *n*, *r*, *s*, when it has a hard trilling sound —*caro* (kah-roh), expensive; *alrededores* (ahl-ray-day-doh-rays), environs. At the beginning of a word it always sounds hard—*rio* (ree-oh), river.

RR is always pronounced hard.

S is pronounced like *s* in *blast*—*sello* (say-lyoh), stamp; *estar* (ayss-tahr), to be.

T and V are pronounced as in English—*tubo* (too-boh), tube; *vino* (vee-noh), wine. T is a little softer than in English.

There is no W in the Spanish alphabet.

X and Y sound as in English—*examen* (eg-sah-mayn), examination; *yo* (yoh), I; *cuyo* (koo-yoh), whose. When standing alone or at the end of a word, *y* is a vowel, and is pronounced *ee*.

Z must be pronounced like *th* in English—*azul* (ah-thool), blue.

There is only one graphic accent in Spanish (´), which indicates where the stress is to be placed. Most Spanish words have the stress on the syllable before the last, unless the accent is somewhere else—*cántara* (kAhn-tah-rah), pitcher; *cantará* (kahn-tah-rAh), he will sing; *cantara* (kahn-tAh-rah), he should, or might sing. The sign ñ, or *tilde*, is not an accent but part of a letter.

Punctuation. Punctuation is the same as in English, with the exceptions that the mark of interrogation is placed below the line (¿) at the beginning of a sentence and is repeated above the line at the end (?), and the mark of exclamation (¡) is also used in the same way (!).

The Articles. The Spanish language has two articles—definite and indefinite. Both have two genders—masculine and feminine. There is, however, a neuter article which is only applied to pronouns and adjectives in order to convey an abstract idea in a definite manner. Masculine and feminine articles have two numbers—singular and plural. The neuter article—*lo* (loh), the—has no plural.

Definite Article

Singular	Plural
Mas.—*el* (ayl), the	*los* (lohss), the
Fem.—*la* (lah), the	*las* (lahss), the

Indefinite Article

Singular	Plural
Mas.—*un* (oon), a, an	*unos* (oo-nohss), some
Fem.—*una* (oon-ah), a, an	*unas* (oo-nahss), some

Note: The article agrees in gender and number with its noun.

MASCULINE NOUN

El libro (lee-broh)	The book
un libro	a book
los libros (lee-brohss)	the books
unos libros	some books

Similarly: *El papel* (pah-payl), the paper; *el sobre* (soh-bray), the envelope.

FEMININE NOUN

la carta (kahr-tah)	The letter
una carta	a letter
las cartas (kahr-tahss)	the letters
unas cartas	some letters

Similarly: *la puerta* (poo-ayr-tah), the door; *la mesa* (may-ssah), the table; *la pluma* (ploo-mah), the pen.

ADJECTIVE OR PRONOUN

lo malo (mah-loh)	Evil
lo bueno (boo-ay-noh)	Good
lo futuro (foo-too-roh)	The future
lo desconocido (dayss-koh-noh-thee-doh)	The unknown
lo mio (mee-oh)	Mine, all that is mine

Note: *Lo* refers to the indefinite and might be translated into English by: "that which is."

THE MONTHS—LOS MESES

January	*enero* (a-nay-roh)
February	*febrero* (fay-bray-roh)
March	*marzo* (mahr-thoh)
April	*abril* (ah-breel)
May	*mayo* (mah-yoh)
June	*junio* (hoo-nee-oh)
July	*julio* (hoo-lee-oh)
August	*agosto* (ah-gohss-toh)
September	*septiembre* (sayp-tee-aym-bray)
October	*octubre* (ok-too-bray)
November	*noviembre* (noh-vee-aym-bray)
December	*diciembre* (dee-thee-aym-bray)

THE DAYS—LOS DIAS

Sunday	*domingo* (doh-meen-goh)
Monday	*lunes* (loo-nays)
Tuesday	*martes* (mahr-tayss)

immediately preceded by *l*, *n*, *r*, *s*, when it has a hard trilling sound—*caro* (kah-roh), expensive; *alrededores* (ahl-ray-day-doh-rays), environs. At the beginning of a word it always sounds hard—*río* (ree-oh), river.

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DEFINITE ARTICLE

	Singular	Plural
Mas.	*el* (ayl), the	*los* (lohss), the
Fem.	*la* (lah), the	*las* (lahss), the

INDEFINITE ARTICLE

	Singular	Plural
Mas.	*un* (oon), a, an	*unos* (oo-nohss), some
Fem.	*una* (oon-ah), a, an	*unas* (oo-nahss), some

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THE DAYS—LOS DIAS

Sunday	*domingo* (doh-meen-goh)
Monday	*lunes* (loo-nays)
Tuesday	*martes* (mahr-tayss)

Wednesday	*miércoles* (mee-ayr-koh-layss)
Thursday	*jueves* (hoo-ay-vayss)
Friday	*viernes* (vee-ayr-nayss)
Saturday	*sábado* (sah-bah-doh)

Note: The months of the year and days of the week do not take capitals in Spanish.

7 THE NUMBERS—LOS NUMEROS

Note: Accents are not put on capital letters in Spanish.

1 *uno* (oo-noh)	7 *siete* (see-ay-tay)
2 *dos* (dohss)	8 *ocho* (oh-choh)
3 *tres* (trayss)	9 *nueve* (noo-ay-vay)
4 *cuatro* (koo-ah-troh)	10 *diez* (dee-ayth)
5 *cinco* (theen-koh)	11 *once* (ohn-thay)
6 *seis* (sayss)	12 *doce* (doh-thay)

a child	*un niño* (neen-yoh)
the house	*la casa* (kah-sah)
a chair	*una silla* (seel-yah)
the ink	*la tinta* (teen-tah)
a pencil	*un lápiz* lah-peeth)
the rule	*la regla* (ray-glah)
the hat	*el sombrero* (sohm-bray-roh)
a flower	*una flor* (flohr)
the tobacco	*el tabaco* (tah-bah-koh)
a wall	*una pared* (pah-rayd)
some pipes	*unas pipas* (pee-pahss)
some pictures	*unos cuadros* (koo-ah-drohss)

Note: *Casa* preceded by the definite article means the house; *without* the def. article, Home.

Gender of Nouns. Nouns signifying dignities, callings and professions peculiar to men are masculine; those identified with women are feminine.

Nearly all nouns ending in *a, d, ión, z* are feminine; those having other terminations are masculine.

Names of living beings are masculine or feminine according to the sex they imply. Important exceptions to the rule are given in the vocabularies.

Plural of Nouns. The plural is formed by adding *s* to all nouns ending in *a, e, o*; and *es* to those ending in *i, y,* or any consonant. If the noun ends in *z*, the plural is formed by dropping the *z* and adding *ces*—*niño*, child; *niños*, children; *hombre*, man;

hombres, men; *bandera,* flag; *banderas,* flags; *botón,* button; *botones,* buttons; *rey,* king; *reyes,* kings; *lápiz,* pencil; *lápices,* pencils.

EXERCISE I

Write out the definite articles corresponding to the following:

1. madre (f.). 2. padre (m.). 3. mesas (f.pl.). 4. libros (m. pl.). 5. niños (m. pl.). 6. casa (f.). 7. sobre (m.). 8. sillas (f. pl.). 9. tinta (f.). 10. lápiz (m.). 11. regla (f.). 12. sombrero (m.). 13. papeles (m. pl.). 14. flor (f.). 15. tabaco (m.). 16. pared (f.). 17. pipas (f. pl.). 18. cuadros (m. pl.).

EXERCISE II

Write out the article appropriate to each of the following nouns:

1. *techo,* ceiling. 2. *sastre,* tailor. 3. *alquiler,* rent. 4. *pared,* wall. 5. *lección,* lesson. 6. *papel,* paper. 7. *diario,* newspaper. 8. *costurera,* seamstress. 9. *nación,* nation. 10. *bastón,* walking-stick. 11. *paz,* peace. 12. *cuadro,* picture. 13. *teniente,* lieutenant. 14. *cama,* bed. 15. *huevo,* egg. 16. *caballo,* horse. 17. *gallina,* hen. 18. *modista,* dressmaker.

Form the plural of the following nouns:

1. *planta,* plant. 2. *tintero,* inkpot. 3. *tren,* train. 4. *cofre,* coffer. 5. *rey,* king. 6. *clavel,* carnation. 7. *perro,* dog. 8. *jabalí,* wild boar. 9. *tierra,* land. 10. *español,* Spaniard. 11. *mar,* sea. 12. *pez,* fish. 13. *muelle,* wharf. 14. *pueblo,* village. 15. *malecón,* embankment. 16. *playa,* shore. 17. *perdiz,* partridge. 18. *reloj,* watch.

LESSON 2

Some Peculiarities of Speech

THE forms of address in common use are *usted* and *ustedes,* which are contracted forms of *vuestra merced* (your honour). *Usted* is usually written *Vd.* or *V.*, and *ustedes* abbreviated to *Vds.*, or simply *Vs.* *Tú* and *vosotros* are the familiar forms used between close friends, or in speaking to children or animals. The feminine forms of *nosotros, vosotros,* are *nosotras, vosotras.*

Possessive Adjectives. These are as follow: Sing., *su,* his, her, its, your; *mi,* my. Plur., *su,* their, your; *nuestro,* our.

The familiar forms of the possessive adjective are *tu*, thy; and *vuestro*, your. The same remarks apply to them as to the familiar forms of the personal pronouns.

Possessive adjectives agree in number with the following noun. The plural is formed by adding *s* to the singular. *Mi*, *tu*, *su* have no gender. When the noun immediately following *nuestro*, *vuestro*, is feminine, these words must be changed to *nuestra*, *vuestra*. As *su*, *sus* stand for his, her, its, their, your, it is necessary sometimes to add *de él* (of him), *de ella* (of her), *de ellos*, *de ellas* (of them), *de Vd.*, or *de Vds.* (of you), to make the meaning quite clear; e.g. *su casa de V.* (your house).

EXERCISE I.

A friend	*Un amigo*	The theatre	*El teatro*
The queen	*La reina*	The coffee-house	*El café*
The drawing-room	*La sala*	An invoice	*Una factura*
A bath	*Un baño*	The draft	*El giro*
The dining-room	*El comedor*	A cheque	*Un cheque*
The kitchen	*La cocina*	The copy	*La copia*
An office	*Un despacho*	The sealing-wax	*El lacre*
A shop	*Una tienda*	The sister	*La hermana*

TRANSLATE: 1. Mi padre. 2. Su libro (de Vd.). 3. Su lápiz (de él). 4. Tu silla. 5. Nuestro papel. 6. Su carta. 7. Mis flores. 8. Sus lecciones (de ellos). 9. Vuestras pipas. 10. Nuestros sombreros. 11. Su goma (de ella). 12. Mi sobre. 13. Vuestra casa. 14. Tu modista. 15. Mis caballos. 16. Su bastón (de él). 17. Nuestro rey 18. Su perro (de ella).

TRANSLATE: 1. Your office. 2. My drafts. 3. Our house. 4. His sealing-wax. 5. My father. 6. Her dogs. 7. Their shops. 8. Your cheques. 9. Our queen. 10. Its dining-room. 11. His stick. 12. Their letters. 13. Its copies. 14. Your invoice. 15. Her kitchen. 16. Our lessons. 17. Thy sister. 18. Your (fam.) friends.

Personal Pronouns. These are as follow:

Singular	*Plural*
yo, I	*nosotros*, we
tú, thou	*vosotros*, you
usted, you	*ustedes*, you
él, he	*ellos*, they
ella, she	*ellas*, they (f.)

The Article. When a feminine noun of two syllables begins with a stressed *a* or *ha*, the masculine form of the article must be

used in the singular only, for the sake of euphony—*el agua*, the water; *las aguas*, the waters, *el arma*, the weapon, *las armas*, the weapons. The prepositions *de* (of, from) and *a* (to, at) in front of the masculine article *el* are elided with the article and become respectively *del* (*de el*) and *al* (*a el*)—*del hombre*, of the man, *al correo*, to the post-office.

Possessive Case. There is no possessive case in Spanish it follows, therefore, that sentences like "the man's hat" must be rendered by "the hat of the man," *el sombrero del hombre*; "your friends' teacher" by "the teacher of your friends," *el profesor de sus amigos*.

Translation of "To Be." The verb "to be" has two forms—*ser* and *estar*. When used in speaking of the existence of physical or moral qualities which are inherent in, or essential to, the nature of persons or things, or when it marks the professions or callings of individuals, "to be" must be translated by *ser*. The passive voice of a verb, and the relation of anything to its owner or holder, are also invariably expressed by *ser*.

When "to be" implies a position, temporary action, or condition of a person or thing, or the existence of any accidental qualities, *estar* must be used. It sometimes happens that the same word may express in Spanish a quality inherent or accidental, when this is the case, *ser* or *estar* must be selected according to the meaning of the sentence.

PRESENT INDICATIVE OF *Ser*

Singular	*Plural*
yo soy, I am	*nosotros somos*, we are
tú eres, thou art	*vosotros sois*, you are
él, ella es, he, she, it, is	*ellos, ellas son*, they are

PRESENT INDICATIVE OF *Estar*

Singular	*Plural*
yo estoy, I am	*nosotros estamos*, we are
tú estás, thou art	*vosotros estáis*, you are
él, ella está, he, she, it, is	*ellos ellas están*, they are

As the polite forms of address *Vd* and *Vds* stand, as has been explained, for "your honour," the verb must be used in the third person, thus you are (your honour is) *Vd es*, you (your honours) are, *Vds son*. In negative sentences, *no* (not) invariably precedes the verb. Personal pronouns acting as sub-

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jects of a verb are nearly always omitted unless by so doing the meaning of the sentence would become ambiguous or the speaker wants particularly to emphasise them. The polite form is never omitted.

EXERCISE II ON *Ser*

Spaniard	*español*	bedroom	*dormitorio*
Englishman	*inglés*	passenger	*pasajero*
foreigner	*extranjero*	station	*estación*
lawyer	*abogado*	building	*edificio*
office	*oficina*	train	*tren*
business	*negocio*	tall	*alto*
business man	*comerciante*	Custom-house	*aduana*
uncle	*tío*	large	*grande*
owner	*dueño*	blue	*azul*
workman	*obrero*	that (one)	*ese*
physician	*médico*	of	*de*
clerk	*empleado*	all	*todos*
manager	*jefe*	who?	*¿ quién ?*
front of a house	*fachada*	yes, sir	*sí señor*
factory	*fábrica*	no sir	*no señor*
		very	*muy*

TRANSLATE INTO ENGLISH: 1 Él es inglés 2 ¿ Son Vds españoles ? 3 Yo no soy abogado 4 Nosotros somos extranjeros 5 ¿ Es ese mi tren ? 6 Nosotros somos empleados 7. ¿ Quién es el jefe ? 8 Vds no son los dueños de la fábrica 9 Yo soy un pasajero de ese tren 10 La fachada de la aduana es azul 11 Su dormitorio (de él) es grande 12 Tú no eres alto 13. ¿ Es Vd comerciante ? 14 Ellos son extranjeros

TRANSLATE INTO SPANISH 1 Are you the manager of the office ? 2 No, sir I am not the manager I am a clerk 3 Who is the lawyer of your friend ? 4 They are our workmen 5 The factory is not very large 6 All his clerks are Englishmen 7 You (plural) are not Spaniards ? 8 Is he the owner of the business ? 9 We are not foreigners 10 Your ticket is blue 11 Are you his uncle ? 12 Is that building the custom-house ? 13 She is (a) dressmaker 14 Who are you ? 15 I am one of his clerks

EXERCISE III ON *Estar*

Buenos Aires	*Buenos Aires*	London	*Londres*
Thames	*El Támesis*	in charge	*encargado*
New York	*Nueva York*	engaged	*empleado*

sea-sick	*mareado*	but	*pero*
ill	*enfermo*	with	*con*
tired	*cansado*	in, on	*en*
the platform	*el andén*	already	*ya*
the garden	*el jardín*	near (to)	*cerca de*
the trunk	*el baúl*	far from	*lejos de*
the mine	*la mina*	at home	*en casa*
a steamer	*un vapor*	neither am I	*Yo tampoco*
Madam	*la señora*	to, on the left	*a la izquierda*
a gentleman	*un caballero*	to, on, the right	*a la derecha*
well	*bien*	I do not think so	*Creo que no*
a little	*un poco*	on board	*a bordo*
here	*aquí*	the bay	*la bahía*
where	*dónde*	Many thanks	*Muchas gracias*
how	*cómo*	not yet	*todavía no*
now	*ahora*	for	*para*

TRANSLATE INTO ENGLISH: 1. ¿ Cómo está Vd. ? 2. No estoy muy bien; estoy muy cansado. 3. ¿ Dónde está el jefe de la estación ? 4. No está aquí; está en el jardín. 5. ¿ Estamos ya en Londres ? 6. No, señora, ahora estamos en Dover. 7. ¿ Está Vd. cansado ? 8. No, señor; ¿ y Vd. ? 9. Yo tampoco; muchas gracias. 10. ¿ Dónde está ella ? 11. Ella está en Nueva York, pero su padre (de ella) está en Buenos Aires. 12. ¿ Están todos los baúles a bordo ? 13. ¿ Quién está en el jardín con los obreros ? 14. Mi amigo está muy lejos de aquí; está empleado en las minas de Colombia. 15. ¿ Está enfermo ? 16. Creo que no.

TRANSLATE INTO SPANISH: 1. Are we in the factory already ? 2. No, sir; we are in the station. 3. Is this the platform for Madrid ? 4. No, sir; the platform for Madrid is on the right. 5. Who is in charge of the trunks ? 6. My uncle, but he is not here yet. 7. How is he ? 8. He is very well, thanks. 9. Is London near the coast ? 10. No; it is on the Thames. 11. Where is the steamer for Montevideo ? 12. To the left of the station, madam. 13. Are you ill ? 14. I am a little sea-sick. 15. Are we near the office ? 16. No; you (plural) are very far from it.

KEYS TO EXERCISES IN LESSON 1

I. 1. la. 2. el. 3. las. 4. los. 5. los. 6. la. 7. el. 8. las. 9. la. 10. el. 11. la. 12. el. 13. los. 14. la. 15. el. 16. la. 17. las. 18. los.

II. 1. el. 2. el. 3. el. 4. la. 5. la. 6. el. 7. el. 8. la. 9. la. 10. el. 11. la. 12. el. 13. el. 14. la. 15. el. 16. el. 17. la. 18. la.

1. plantas. 2. tinteros. 3. trenes. 4. cofres. 5. reyes. 6. claveles. 7. perros 8. jabalíes. 9. tierras. 10. españoles. 11. mares. 12. peces. 13. muelles. 14. pueblos. 15. malecones. 16. playas. 17. perdices. 18. relojes.

LESSON 3

Adjectives and the Verb "to have"

ADJECTIVES generally follow the substantives to which they refer, and agree with them in gender and number. Adjectives ending in *o* become feminine by changing this final letter into *a*—*el plato blanco*, the white plate; *la taza blanca*, the white cup. Those ending in *an*, *on*, or signifying nationality and ending in a consonant, form their feminine by adding an *a*—*un muchacho holgazán*, a lazy boy; *una muchacha holgazana*, a lazy girl. All other adjectives have only one termination for both genders.

The plural of adjectives is formed in the same manner as the plural of nouns, by adding *s* or *es* according to their termination. An adjective qualifying two or more words of different gender takes the masculine plural form—*el caballero y la señora son españoles*, the gentleman and the lady are Spanish.

The adjectives *alguno*, some; *bueno*, good; *malo*, bad; *ninguno*, not any, none; *cualquiera*, any, are contracted to *algún*, *buen*, *mal*, *ningún*, and *cualquier* before a masculine singular noun—*un buen hombre*, a good man; *ningún cuadro*, no picture. *Cualquiera* is also contracted in front of a feminine singular noun—*cualquier calle*, any street. *Grande*, meaning great, is contracted to *gran*, and placed before the noun it qualifies—*un gran pintor*, a great painter.

EXERCISE I on *Ser* and *Estar*.

1. Are you business men from Madrid? 2. No; I am (a) lawyer and my friends are physicians. 3. Is the steamer in the bay? 4. No, sir; not yet. 5. Is that gentleman your father? 6. No; he is my uncle. 7. Are we near his factory? 8. No; it is very far from here. 9. Where are my trunks? 10. They are on the platform, number five. 11. Are you sea-sick? 12. No, thanks; I am very well. 13. Is the door of the dining-room in

the garden? 14 No, it is now in the station to the right of the booking-office 15 Are you (plural) foreigners? 16 Yes, sir, we are Spaniards 17 Where are we (fem) now? 18 You are in the custom-house 19 Is the clerk in the office? 20 No, madam, he is on board the steamer from Valparaiso

VOCABULARY

the month	*el mes*	the anchor	*el ancla* (*f*)
the salary	*el salario*	the ship	*el buque*
the bird	*el ave* (*f*)	the wing	*el ala* (*f*)
the neighbour	*el vecino*	pronunciation	*pronunciación*
hunger	*el hambre*	the eye	*el ojo*
the flour	*la harina*	the soul	*el alma* (*f*)
a beggar	*un mendigo*	a jewel	*una joya*
the bread	*el pan*	the tree	*el arbol*
short	*corto*	small	*pequeño*
German	*Aleman*	beautiful	*hermoso*
narrow	*estrecho*	immortal	*inmortal*
long	*largo*	the cigar	*el cigarro*
polite	*cortés*	Italian	*Italiano*
jolly	*alegre*	difficult	*dificil*
the weather	*el tiempo*	hard	*duro*
too	*demasiado*	white	*blanco*

I do not understand—*no comprendo*

Note The nouns marked feminine take for euphony the masculine definite article in the singular In the plural they take the definite and indefinite article both feminine

EXERCISE II

TRANSLATE 1 A clerk's salary 2 The horses' eyes 3 The beggar's bread is hard 4 My neighbour's tree is too high 5 Man's soul is immortal 6 The American flour is very good 7 The streets are long and narrow 8 The bird's wings are short and white 9 The German ship's anchor is too small 10 Her sister's jewels are beautiful 11 The French bread is good 12 My father and mother are well 13 The house and the garden are large 14 Your Italian friend (fem) is very polite and jolly

Comparision of Adjectives The comparative is formed by placing *mas* (more) and *menos* (less) in front of the adjective—*más blanco*, whiter, *menos duro* less hard The comparative forms of the adjectives *grande*, *pequeño*, *bueno*, *malo* are *mayor*,

menor, mejor, peor. These words have no gender, and they form the plural in the usual manner.

In comparisons of equal degree, "so-as" and "so-much-as" are translated by *tan-como* and *tanto-como* respectively. *Tanto* being an adjective, it agrees in gender and number with the following noun. "Than" is translated by *que*—*el comedor es mayor que la sala*, the dining-room is larger than the drawing-room. Whenever "than" is followed in the English sentence by a verb, it is rendered in Spanish by *de lo que*—*es más rico de lo que dice*, he is richer than he says.

Note.—"Mayor," bigger or larger, when referring to humans means older. The comparative "más grande" is used when referring to physical size.

Demonstrative adjectives and pronouns agree in gender and number with the nouns to which they relate. They are as follows:

	Singular.			*Plural.*	
	M.	F.	N.	M.	F.
This	*este*	*esta*	*esto*	*estos*	*estas*
That	*ese*	*esa*	*eso*	*esos*	*esas*
That	*aquel*	*aquella*	*aquello*	*aquellos*	*aquellas*

The neuter forms have no plural. *Este* denotes proximity; *ese*, moderate distance, and *aquel*, remoteness (that yonder).

Exercise III.

1. This book is larger than that. 2. Is that the station? 3. That stick is my brother's. 4. These newspapers are Spanish. 5. I do not understand that. 6. It is not that. 7. These cigars are better than those. 8. My brother is not so tall as you. 9. This lesson is not so difficult. 10. Those houses are nearer than the factory.

The Verb To Have. The verb to have may be translated either by *tener* or *haber* *Tener* is used as an active verb denoting possession—*yo tengo un sombrero*, I have a hat.

Haber is simply an auxiliary verb, and it can therefore never be used except before a past participle—*yo he comprado un bastón*, I have bought a stick.

Present Indicative of *Tener*.

Singular.	*Plural.*
yo tengo, I have	*nosotros tenemos*, we have
tú tienes, thou hast	*vosotros tenéis*, you have
él, ella, Vd. tiene, he, she, it has, you have	*ellos, ellas, Vds. tienen*, they, you have

PRESENT INDICATIVE OF *Haber*.

Singular.	*Plural.*
yo he, I have	*nosotros hemos* we have
tú has, thou hast	*vosotros habéis*, you have
él, ella, Vd. ha, he, she has, you have	*ellos ellas, Vds., han*, they, you have

VOCABULARY

looking-glass	*espejo*	bag	*maleta*
piano	*piano*	boots	*botas*
dress	*vestido*	pair	*par*
sugar	*azúcar*	room	*cuarto*
situation	*destino*	cashier	*cajero*
matches	*fósforos*	seen	*visto*
address	*dirección*	left	*dejado*
written	*escrito*	come	*venido*
bought	*comprado*	gone	*ido*
sold	*vendido*	lost	*perdido*
received	*recibido*	to write	*escribir*
found	*encontrado*	to sign	*firmar*
to have to	*tener que*	to speak	*hablar*
who	*quién*	why	*por qué*
as soon as possible	*lo antes posible*	that, which	*que*
		enough	*bastante*
to be hungry, thirsty, cold, hot, sleepy, afraid, ashamed		*tener hambre, sed, frío, calor, sueño, miedo, vergüenza.*	

EXERCISE IV.

TRANSLATE: 1. I have a good looking-glass in my room. 2. We have left our bags in the train 3. Are you thirsty? 4. Why have you not gone to London? 5. Have they found her blue dress? 6. Has she enough sugar? 7 We have no matches in the office. 8. I have lost your address 9. He has a good situation in Mexico (Méjico). 10 Have they come? 11 Have I to sign that paper? 12. You have to write as soon as possible.

KEY TO EXERCISES IN LESSON 2.

I. 1. My father 2. Your book 3. His pencil. 4. Thy chair. 5. Our paper 6. His, her, your letter. 7 My flowers. 8 Their lessons. 9 Your (pl.) pipes 10. Our hats 11. Her gum 12. My envelope. 13 Your house 14 Thy dressmaker. 15. My horses 16. His stick. 17. Our king. 18. Her dog.

1. Su despacho (de Vd.). 2. Mis giros. 3. Nuestra casa. 4. Su lacre (de él). 5. Mi padre. 6. Sus perros (de ella). 7. Sus tiendas (de ellos). 8. Sus cheques (de Vd.). 9. Nuestra reina. 10. Su comedor. 11. Su bastón (de él). 12. Sus cartas (de ellos). 13. Sus copias. 14. Su factura (de Vds.). 15. Su cocina (de ella). 16. Nuestras lecciones. 17. Tu hermana. 18. Tus amigos.

II. 1. He is (an) Englishman. 2. Are you Spaniards? 3. I am not (a) lawyer. 4. We are foreigners. 5. Is that my train? 6. We are clerks. 7. Who is the manager? 8. You (pl.) are not the owners of the factory. 9. I am a passenger in (of) that train. 10. The frontage of the custom-house is blue. 11. His bedroom is large. 12. Thou art not tall. 13. Are you (a) business man? 14. They are foreigners.

1. ¿ Es Vd. el jefe de la oficina? 2. No, señor, no soy el jefe; soy un empleado. 3. ¿ Quién es el abogado de su amigo? 4. Ellos son nuestros obreros. 5. La fábrica no es muy grande. 6. Todos sus empleados son ingleses. 7. Vds. no son españoles. 8. ¿ Es él el dueño del (de el) negocio? 9. Nosotros no somos extranjeros. 10. Su billete (de Vd.) es azul 11. ¿ Es Vd. su tío (de él)? 12. ¿ Es ese edificio la aduana? 13. Ella es modista. 14. ¿ Quién es Vd.? 15. Yo soy uno de sus empleados (de él).

III. 1. How are you? I am not very well; I am very tired. 3. Where is the manager of the station (station master)? 4. He is not here; he is in the garden. 5. Are we in London already? 6. No, madam; we are now in Dover. 7. Are you tired? 8. No, sir; and you? 9. Neither am I; many thanks. 10. Where is she? 11. She is in New York, but her father is in Buenos Aires. 12. Are all the trunks on board? 13. Who is in the garden with the workmen? 14. My friend is very far from here; he is engaged in the mines of Colombia. 15. Is he ill? 16. I do not think so.

1. ¿ Estamos ya en la fábrica? 2. No, señor; estamos en la estación. 3. ¿ Es este el andén para Madrid? 4. No, señor; el andén para Madrid está a la derecha. 5. ¿ Quién está encargado de los baúles? 6. Mi tío; pero no está aquí todavía. 7. ¿ Cómo está (él)? 8. Está muy bien, gracias 9. ¿ Está Londres cerca de la costa? 10. No, está en el Támesis. 11. ¿ Dónde está el vapor para Montevideo? 12. A la izquierda de la estación, señora. 13. ¿ Está Vd. enfermo? 14. Estoy un poco mareado. 15. ¿ Estamos cerca de la oficina? 16. No, Vds. están muy lejos (de ella).

LESSON 4

On Verbs and Pronouns

The infinitives of all verbs end either in *ar* (first conjugation), *er*, or *ir* (second and third conjugations). The present participle or gerund of the first conjugation is formed by changing the termination *ar* of the infinitive into *ando*; and that of the second and third conjugations by changing the termination *er*, *ir* of the corresponding infinitives into *iendo*. The present participle describes an action in a state of progression—*hablar*, to speak, *hablando*, speaking; *comer*, to eat; *comiendo*, eating, *abrir*, to open; *abriendo*, opening. "To be" in front of a present participle is always translated by *estar*.

VOCABULARY.

to sing	*cantar*	to thunder	*tronar*
to walk	*pasear*	to sign	*firmar*
to buy	*comprar*	to drink	*beber*
to sell	*vender*	to run	*correr*
to rain	*llover*	to learn	*aprender*
to live	*vivir*	to print	*imprimir*
milk	*leche* (*f.*)	glass	*vaso*

EXERCISE I.

TRANSLATE INTO SPANISH: 1. She is singing. 2. They are walking. 3. We are running. 4. They are selling. 5. I am learning Spanish. 6. It is thundering. 7. Are you (sing.) writing a letter to my friend? 8. Where are they living now? 9. He is opening the door.

Past Participle. The past participle of all regular verbs is formed from the infinitive by changing its termination *ar*, *er*, *ir* into *ado* for the first conjugation, and into *ido* for the second and third conjugations—*hablar*, *hablado*, spoken; *comer*, *comido*, eaten; *recibir*, *recibido*, received.

VOCABULARY.

to change	*cambiar*	to offer	*ofrecer*
to arrange	*arreglar*	to grant	*conceder*
to reject	*rechazar*	to read	*leer*
to ask	*preguntar*	to lose	*perder*

to ask for	*pedir*	to go	*ir*
money	*dinero*	to come	*venir*
offer	*oferta*	name	*nombre*
year	*año*	goods	*géneros*
new	*nuevo*	customer	*cliente*
report	*informe*	bank	*banco*
docks	*muelle*	partner	*socio*
bonus	*bonificación*	particulars	*detalles*
messenger	*mensajero*	manufacturer	*fabricante*
morning	*la mañana*		

NOTE.—*Mañana* by itself means *tomorrow.* *La* (*una*) *mañana* the (a) morning.

EXERCISE II.

TRANSLATE INTO SPANISH : 1. She has changed her money. 2. They (fem.) have arranged the papers. 3. His partner has rejected the offer. 4. Have you asked his name ? 5. We have not offered new goods this year. 6. The manufacturers have granted a bonus to their customers. 7. I have not read the report yet. 8. My friend has lost his situation. 9. Have you (pl.) received the drafts ? 10. We (fem.) have asked for particulars of the offer. 11. The clerk has gone to the post office. 12. Your messenger has come late this morning.

The Past Definite. The past definite is frequently translated by the compound tense—*¿ ha visto Vd. su libro ?* did you see his book ? *he escrito una carta esta mañana,* I wrote a letter this morning ; *ha ido al casino ante de las* (before of the) *doce,* he went to the club before 12 o'clock.

The personal object of a verb is always preceded by the preposition *a*—*he encontrado a su primo,* I have met his cousin.

Relative and Interrogative Pronouns. Relative pronouns are those which relate to a previous word or phrase. When used in asking a question they are called interrogative, and are then written with an accent.

	Singular.	*Plural.*
who	*quien*	*quienes*
whose	*cuyo*	*cuyos*
of, to, for, etc.,	*de, a, para,* etc.,	*de, a, para,* etc.,
whom	*quien*	*quienes*

These words have no gender, except *cuyo* which takes the gender and number of the following noun—*el autor cuyos libros he leido,*

the author whose books I have read. The relative pronoun must always be expressed in Spanish, although in English it is sometimes omitted. When *whom* does not follow a preposition it may be rendered by *que—el empleado que han despedido*, the clerk (whom) they have dismissed.

The relative pronoun *who* is generally translated by *que—el hombre que ha abierto la puerta*, the man who opened the door. But *who* after the verb to be is usually rendered by *quien, quienes—¿ es Vd. quien ha enviado esta factura ?* is it you who have sent this invoice ? In phrases of this kind, *who* may also be translated by *el que, la que, los que, las que*, according to the gender and number of the subject of the sentence—*yo soy él que ha dicho eso*, it is I who said that.

VOCABULARY.

theatre	*teatro*	staircase	*escalera*
it is I	*soy yo*	to knock	*llamar*
last night	*anoche*	downstairs	*abajo*
to dine	*cenar*	merchant	*comerciante*
to bring	*traer*	to smoke	*fumar*
there	*ahí*	the whole morning	*toda la mañana*
bank-note	*billete de banco*		

EXERCISE III.

TRANSLATE INTO SPANISH: 1. Who is there ? 2. It is I. 3. Who (pl.) went to the theatre last night ? 4. That is the merchant whose invoice we received this morning. 5. Whose pencil is this (translate " of whom is this pencil ") ? 6. To whom have you spoken on the staircase ? 7. For whom is that invoice ? 8. The man (whom) we have seen in the street is the manager of the office. 9. It is we who changed the bank-note. 10. Is it you who knocked at the door ? 11. No ; the man who knocked is downstairs. 12. With whom have you dined ? 13. I have not dined yet ; I have been very busy the whole morning. 14. Who is smoking in the drawing-room ?

The other interrogative and relative pronouns are as follow :

	Singular.	*Plural.*
which one ?	*¿ cual ?*	*¿ cuales ?*
of which	*cuyo*	*cuyos*
to, for, etc., which	*a, para*, etc., *cual*	*a, para*, etc., *cuales*
that	*que*	
what	*qué*	

EXAMPLES ¿*Cual es su libro?* which is his book? *la carta cuya copia ha desaparecido* the letter the copy of which has disappeared, *la letra que he firmado* the bill that I have signed; ¿*Que billete?* what ticket?

The interrogative adjective *which* may be translated by *qué*—¿*que palabra?* which word? The relative pronoun *which* is nearly always translated by *que*, except when it is dubitative—*los géneros que Vd ha enviado*, the goods which you have sent; *no sé cual es el mejor*, I do not know which is the best

It must be noted that the subject of a Spanish relative sentence is usually placed after the verb—*las noticias que ha traido el vapor*, the news which the steamer has brought Whenever *which* relates to a full previous sentence, it is rendered in Spanish by *lo que* or *lo cual*—*ha dicho que han llegado, lo cual no es verdad*, he has said that they have arrived, which is not true *Who* and *which* (relative) may sometimes be translated by *el cual, la cual, los cuales, las cuales*—*hemos comprado dos maquinas de escribir, las cuales* (or *que*) *estan arriba* we have bought two typewriters, which are upstairs, *he encontrado a su agente, el cual esta en Londres*, I have met his agent, who is in London

The words *what a!* and *how!* in exclamations, are translated by ¡*Que!*—¡*Que lastima!* What a pity! ¡*Que extraño!* How strange!

VOCABULARY

dictionary	*diccionario*	box	*caja*
to telegraph	*telegrafiar*	lovely	*lindo*
strange	*extraño*	cashier	*cajero*
to communicate	*comunicar*	to check	*comprobar*
		to order	*pedir*
at once	*en el acto*	answer	*respuesta*

EXERCISE IV

TRANSLATE INTO SPANISH 1 Which dictionary? 2 Which drafts? 3 Which one have you brought? 4 I have written the report I promised (translate, "which I have promised"). 5. I do not know which ones he has 6 He has not telegraphed yet, which is very strange 7 We have ordered ten boxes, which have not arrived yet 8 I have communicated the news to the cashier, who has checked the accounts at once. 9 What an answer! 10 How lovely!

KEYS TO EXERCISES IN LESSON 3.

(I) 1. ¿ Son Vds. comerciantes de Madrid ? 2. No ; yo soy abogado y mis amigos son médicos. 3. ¿ Está el vapor en la bahía ? 4. No, señor ; todavía no. 5. ¿ Es ese caballero su padre (de Vd.) ? 6. No ; es mi tío. 7. ¿ Estamos cerca de su fábrica ? 8. No ; está muy lejos de aquí. 9. ¿ Donde están mis baules ? 10. Están en el andén número cinco. 11. ¿ Está Vd. mareado ? 12. No, gracias ; estoy muy bien. 13. ¿ Está la puerta del (de el) comedor en el jardín ? 14. No ; ahora está en la estación, a la derecha de la taquilla. 15. ¿ Son Vds. extranjeros ? 16. Sí, señor ; somos españoles. 17. ¿ Donde estamos (nosotras) ahora ? 18. Vds. están en la aduana. 19. ¿ Está el empleado en la oficina ? 20. No, señora ; está a bordo del vapor de Valparaíso.

(II) 1. El salario de un empleado. 2. Los ojos de los caballos. 3. El pan del mendigo está duro. 4. El árbol de mi vecino es demasiado alto. 5. El alma del hombre es inmortal. 6. La harina americana es muy buena. 7. Las calles son largas y estrechas. 8. Las alas de los pájaros son cortas y blancas. 9. El ancla del barco alemán es demasiado pequeña. 10. Las joyas de su hermana (de ella) son hermosas. 11. El pan francés es bueno. 12. Mi padre y mi madre están bien. 13. La casa y el jardín son grandes. 14. Su amiga (de V.) italiana es muy cortés y alegre.

(III) 1. Este libro es más grande que aquel. 2. ¿ Es esa la estación ? 3. Ese bastón es de mi hermano. 4. Estos periódicos son españoles. 5. No comprendo eso. 6. No es eso. 7. Estos cigarros son mejores que aquellos. 8. Mi hermano no es tan alto como V. 9. Esta lección no es tan difícil. 10. Esas casas están más cerca que la fábrica.

(IV) 1. Tengo un buen espejo en mi cuarto. 2. Hemos dejado nuestras maletas en el tren. 3. ¿ Tiene V. sed ? 4. ¿ Por qué no ha ido V. a Londres ? 5. ¿ Han encontrado su traje azul (de ella) ? 6. ¿ Tiene (ella) bastante azúcar ? 7. Nosotros no tenemos fósforos en la oficina. 8. He perdido su dirección (de V.). 9. El tiene un buen destino en Méjico. 10. ¿ Han venido (ellos) ? 11. ¿ Tengo que firmar ese papel ? 12. V. tiene que escribir lo antes posible.

LESSON 5

How Verbs are Conjugated

All Spanish verbs, as we have already noted, are limited to three conjugations, which are distinguished thus: verbs ending in *ar* belong to the first conjugation, those ending in *er* to the second, and those ending in *ir* to the third. Verbs may be regular or irregular, personal or impersonal, active or neuter, and reflexive. Regular verbs are those which in their conjugation follow the rules laid down for the model verb of their termination; irregular verbs, therefore, are those which deviate from the regular form. Impersonal verbs are those verbs which can only be conjugated in the third person; active verbs those which express an action transmissible to another person or object; neuter verbs express an action or state that cannot be transmitted; and a verb is reflexive when the subject is at the same time the object to whom the action is transmitted.

The present indicative of all regular verbs of the first conjugation, which have their termination in *ar*, is obtained by adding the terminations *o, as, a, amos, áis, an* to the stem. *Comprar*, to buy, may be taken as a model for the first conjugation.

Present Indicative of *Comprar*

Singular.	*Plural.*
compr-o, I buy	*compr-amos*, we buy
compr-as, thou buyest	*compr-áis*, you buy
compr-a, he, she buys, you buy	*compr-an*, they, you buy

Questions are formed in Spanish simply by putting the subject after the verb, and negative sentences by placing the adverb *no* in front of the verb. The English auxiliary verb to do is never translated.

Vocabulary.

to use	*usar*	to employ	*emplear*
to advise	*avisar*	to sign	*firmar*
to draw	*girar*	to take	*tomar*
to travel	*viajar*	to accept	*aceptar*
to work	*trabajar*	at sight	*a la vista*

secretary	*secretario*	the hour	*la hora*
tea	*té*	terms	*condiciones*
coffee	*café*	daily	*diariamente*
winter	*invierno*	the milk	*la leche*
thank you	*gracias*		

EXERCISE I

TRANSLATE INTO SPANISH 1 I use large envelopes 2 My friend employs two servants 3 We do not advise (to) our customers 4 Does the secretary sign all (the) cheques? 5 They do not draw at sight 6 Do all the clerks speak Spanish? 7 He does not travel in winter 8 They do not accept our terms 9 Do they work many hours daily? 10 Do you take tea or coffee? 11 I take coffee with milk thank you

The present indicative of all regular verbs of the second conjugation which terminate in *er* is formed by adding to the stem the terminations *o, es, e emos, éis, en* *Beber*, to drink, is a model for this conjugation

PRESENT INDICATIVE OF *Beber*

Singular	*Plural*
beb o, I drink	*beb emos* we drink
beb es, thou drinkest	*beb éis*, you drink
beb e, he, she drinks you drink	*beb en*, they, you drink

VOCABULARY

to learn	*aprender*	to believe	*creer*
to run	*correr*	to answer	*responder*
to eat	*comer*	to fear	*temer*
to sell	*vender*	to owe	*deber*
to promise	*prometer*	fast	*de prisa*
foreign	*extranjero*	the quarter	*el trimestre*
the language	*el idioma*	to understand	*comprender*
shopkeeper	*tendero*	explanation	*explicación*
the consequences	*las consecuencias*		

EXERCISE II

TRANSLATE INTO SPANISH 1 He learns foreign languages 2 That horse runs very fast 3 Do you eat much bread? 4 The shopkeeper does not sell much now 5 Do they not understand your explanation? 6 I believe they are not English 7 Why do they not answer? 8 Because they fear the consequences 9 I do not promise that

The present indicative of all regular verbs of the third conjugation, which terminate in *ir*, is formed by adding to the stem the terminations *o, es, e, imos, ís, en*. *Cumplir*, to fulfil, may be taken as a model

PRESENT INDICATIVE OF *Cumplir*.

Singular	*Plural.*
cumpl-o, I fulfil	*cumpl-imos*, we fulfil
cumpl-es, thou fulfillest	*cumpl-ís*, you fulfil
cumpl-e, he, she fulfils, you fulfil	*cumpl-en*, they, you fulfil

VOCABULARY.

to live	*vivir*	to admit	*admitir*
to receive	*recibir*	to discuss	*discutir*
to go up	*subir*	to decide	*decidir*
to attend	*asistir*	to supply	*surtir*
seldom	*raramente*	the price	*el precio*
spring	*primavera*	promises	*promesas*
several	*varias*	money	*dinero*
the firm	*la casa*	European	*europeo*
to distribute	*repartir*	the meeting	*la reunión*
	every week	*todas las semanas*	

EXERCISE III.

TRANSLATE INTO SPANISH. 1. He does not live here now. 2. Do you receive news from America every week ? 3. Why do they not admit children ? 4. We do not discuss that. 5. The prices very seldom go up in the spring. 6. What do you decide ? 7. She never fulfils her promises. 8. Who distributes the money ? 9. We supply several European firms. 10. I do not attend (to) all their meetings.

KEYS TO THE EXERCISES IN LESSON 4.

(I). 1. (Ella) está cantando. 2. Están andando. 3. Estamos corriendo. 4. Están vendiendo. 5. Estoy aprendiendo español. 6. Está tronando. 7. ¿ Está Vd escribiendo una carta a mi amigo ? 8. ¿ Dónde están viviendo ahora ? 9. Está abriendo la puerta.

(II). 1. (Ella) ha cambiado su dinero. 2. (Ellas) han arreglado los papeles. 3. Su socio ha rechazado la oferta. 4. ¿ Ha preguntado Vd su nombre ? 5. No hemos ofrecido géneros nuevos este año. 6. Los fabricantes han concedido una bonifica-

ción a sus clientes. 7. No he leído el informe todavía. 8. Mi amigo ha perdido su destino. 9. ¿ Han recibido Vds los giros del banco ? 10. (Nosotras) hemos pedido detalles de la oferta. 11. El empleado ha ido al correo. 12. Su mensajero (de Vd) ha venido tarde esta mañana.

(III). 1. ¿ Quién está ahí ? 2. Soy yo. 3. ¿ Quiénes fueron al teatro anoche ? 4. Ese es el comerciante, cuyo factura hemos recibido esta mañana. 5. ¿ De quién es este lápiz ? 6. ¿ A quién ha hablado Vd en la escalera ? 7. ¿ Para quién es esa factura ? 8. El hombre que hemos visto en la calle es el jefe de la oficina. 9. Nosotros somos los que hemos cambiado el billete de banco. 10. ¿ Es Vd quién ha llamado a la puerta ? 11. No ; el hombre que ha llamado está abajo. 12. ¿ Con quién ha cenado Vd ? 13. No he cenado todavía ; he estado ocupado toda la mañana. 14. ¿ Quién está fumando en la sala ?

(IV). 1. ¿ Cuál diccionario ? 2. ¿ Qué giros ? 3. ¿ Cuál ha traído Vd ? 4. He escrito el informe que he prometido. 5. Yo no sé cuales tiene. 6. No ha telegrafiado todavía, lo cual es muy extraño. 7. Hemos pedido diez cajas, las cuales no han llegado todavía. 8. He comunicado las noticias al cajero, el cual ha comprobado las cuentas en el acto. 9. ¡ Qué respuesta ! 10. ¡ Qué lindo !

LESSON 6

Possessive Pronouns and More About Verbs

THE relative superlative is formed by putting *el más, la más* (the most), in front of the positive adjective : *el más alto,* the highest ; *el más negro,* the blackest. A superlative of inferiority is obtained in a similar manner by using *el menos, la menos* (the least) : *el menos rápido,* the least quick.

The absolute superlative, which in English is made with the adverbs very, most, extremely, is formed in Spanish by placing *muy* before the positive adjective, or by affixing to it the terminations *ísimo, ísima, ísimos, ísimas,* according to the gender and number of the noun it qualifies : *fácil, muy fácil, facilísimo,* easy, very easy, most, extremely easy. If the adjective ends in a vowel, the terminations are affixed after dropping the final

vowel: *grande, muy grande, grandísimo,* large, very large, extremely large. Adjectives ending in *co, go, ble, z,* change those letters into *qu, gu, bil,* and *c,* before affixing the superlative terminations: *notable, notabilísimo,* notable, very notable

Among important superlatives irregularly formed are the following: *fuerte* (strong), *fortísimo*, *bueno* (good), *bonísimo*; *nuevo* (new), *novísimo*; *fiel* (faithful), *fidelísimo*; *sabio* (wise), *sapientísimo.* Some adjectives have an irregular absolute superlative, besides that ending in *ísimo.* The chief are: *bueno* (good), *óptimo*; *malo* (bad), *pésimo*; *grande* (large), *máximo*; *pequeño* (small), *mínimo*; *alto* (high), *supremo*; *bajo* (low), *ínfimo.*

Possessive Pronouns. The possessive pronouns are as follow:

Singular.	*Plural.*
mío, mine	*nuestro*, ours
tuyo, thine	*vuestro*, yours
suyo, his, hers, yours	*suyo*, theirs, yours

Possessive pronouns agree in gender and number with the substantive to which they relate, and are preceded by the definite articles *el, la, los, las* *él ha traido sus cartas, pero yo he olvidado las mías*; he has brought his letters, but I have forgotten mine.

In sentences formed with the verb to be, meaning to belong to, the words *el, la, los, las,* are omitted: *esa caja no es nuestra*; that box is not ours. When the possessive pronouns are preceded in English by *of*, this preposition, as well as the article, is omitted in Spanish: *un libro suyo (de ella)*; a book of hers.

The possessive adjectives my, his, your, and so on, are sometimes translated by the possessive pronouns, and then placed after the noun they qualify in order to emphasise their meanings: *eso no es deber mío*; that is not my duty. As in the case of the possessive adjectives, *de él, de ella, de Vd.,* and so on should sometimes be used instead of *suyo, suya,* and the like, for the sake of clearness

Imperfect Indicative. We can now pass to consider the imperfect indicative of both irregular and regular verbs.

IMPERFECT INDICATIVE OF *Ser.*

Singular.	*Plural.*
era, I was	*éramos*, we were
eras, thou wert	*erais*, you were
era, he, she was, you were	*eran*, they, you were

IMPERFECT INDICATIVE OF *Estar.*

Singular.	*Plural.*
estaba, I was	*estábamos*, we were
estabas, thou wert	*estabais*, you were
estaba, he, she was, you were	*estaban*, they, you were

The imperfect indicative can also be translated I used to be, and so on.

Sentences formed with was, were, and a present participle are sometimes literally translated. In all phrases of this kind, to be must always be rendered by *estar*, not *ser*, as the sentence then conveys the idea of what was being done at the time of reference only; thus: she was singing, *estaba cantando*.

IMPERFECT INDICATIVE OF *Tener.*

Singular.	*Plural.*
tenía, I had	*teníamos*, we had
tenías, thou hadst	*teníais*, you had
tenía, he, she, you had	*tenían*, they, you had

IMPERFECT INDICATIVE OF *Haber.*

Singular.	*Plural.*
había, I had	*habíamos*, we had
habías, thou hadst	*habíais*, you had
había, he, she, you had	*habían*, they, you had

VOCABULARY.

expensive	*caro*	short	*corto*
exercise	*tema*	difficult	*difícil*
phrase	*frase*	easy	*fácil*
to affirm	*afirmar*	happy	*feliz*
to think	*creer*	neither—nor	*ni—ni*
or	*o*	mistake	*equivocación*

I do not know *no sé.*

EXERCISE I.

TRANSLATE INTO SPANISH: 1. Whose hat is this? 2. Mine. 3. Have you sold his goods or mine? 4. I have neither sold his nor yours. 5. Is your house more expensive than ours? 6. I do not know, but I think ours is more expensive. 7. Her exercises are the shortest, but they are most difficult. How are yours? 8. Mine are easier than hers. 9. He is not my friend. 10. A phrase of his. 11. They are extremely happy. 12. They affirm those mistakes are not theirs.

The *first conjugation verbs* form the imperfect indicative by adding to the stem the terminations *aba, abas, aba, ábamos, abais, aban.* Verbs of the *second* and *third conjugations* add the termination *ía, ías, ía, íamos, íais, ían.*

IMPERFECT INDICATIVE OF *Comprar.*

Singular.	*Plural.*
compr-aba, I was	*compr-ábamos*, we were
compr-abas, buying, etc.	*compr-abais*, buying, etc.
compr-aba	*compr-aban*

VOCABULARY.

to change	*cambiar*	to govern	*gobernar*
to hide	*ocultar*	to fight	*luchar*
to hire	*alquilar*	to spend	*gastar*
to snow	*nevar*	key	*llave* (f.)
motor-car	*automóvil*	estate	*hacienda*
absent	*ausente*	top	*cumbre* (f.)
mountain	*montaña*	while	*mientras*
at home	*en casa*	soldier	*soldado*
to administer	*administrar*	to help	*ayudar*
a great deal of	*mucho*	advertisement	*anuncio*

EXERCISE II.

TRANSLATE INTO SPANISH: 1. He used to change all his banknotes at the post-office. 2. She used to hide the key. 3. I used to hire a motor-car every morning. 4. They used to administer the estate while the owner was absent. 5. The soldiers were fighting on the top of the mountain. 6. The old firm used to spend a great deal of money in advertisements. 7. I was not at home that day. 8. It had been snowing the whole morning.

IMPERFECT INDICATIVE OF *Beber.*

Singular.	*Plural.*
beb-ía, I was	*beb-íamos*, we were
beb-ías, drinking, etc.	*beb-íais*, drinking, etc.
beb-ía	*beb-ían*

VOCABULARY.

to dine	*comer*	to do	*hacer*
to run	*correr*	to light	*encender*
to sell	*vender*	to sew	*coser*
work	*trabajo*	continent	*continente*

low	*bajo*	price	*precio*
fire	*fuego*	young	*joven*
to read	*leer*	to rain	*llover*

Exercise III

Translate into Spanish 1 I used to dine with my English friends 2 His horse used to run more than mine 3 She used to do my work when I was on the Continent 4 Was it you who was knocking at the door? 5 Who used to light the fire in your room? 6 They used to sell at lower prices 7 She used to sew a great deal when she was young 8 We used to read when it was raining

Imperfect Indicative of *Cumplir.*

Singular		*Plural*	
cumpl-ía, I was		*cumpl-íamos*, we were	
cumpl-ías fulfilling, etc.		*cumpl-íais*	fulfilling, etc.
cumpl-ía		*cumpl-ían*	

Vocabulary

to write	*escribir*	to sleep	*dormir*
to open	*abrir*	to distribute	*distribuir*
to live	*vivir*	to come	*venir*
to correct	*corregir*	nearly	*casi*
camp	*campamento*	window	*ventana*
profits	*ganancias*	among	*entre*
mail	*correo*	near	*cerca*
river	*río*	early	*temprano*
at that time	*entonces*	exercises	*temas*
bookkeeper	*tenedor de libros*		
at daybreak	*al amanecer*		
shareholders	*accionistas*		
teacher	*profesor*		

Exercise IV

Translate into Spanish 1 We used to write nearly all their letters 2 The soldiers used to sleep in the camp 3 He used to open all the windows 4 They used to distribute the profits among the shareholders 5 We were living near the river 6 Who was the bookkeeper at that time? 7 They had no agents in Paris 8 She used to come very early 9. The teacher used to correct his exercises 10 We used to receive the mail at daybreak.

KEYS TO EXERCISES IN LESSON 5.

(I) 1. (Yo) uso sobres grandes. 2. Mi amigo emplea dos criados. 3. (Nosotros) no avisamos a nuestros clientes. 4. ¿ Firma el secretario todos los cheques ? 5. No giran a la vista. 6. ¿ Hablan todos los empleados español ? 7. No viaja en el invierno. 8. No aceptan nuestras condiciones. 9. ¿ Trabajan muchas horas diariamente ? 10. ¿ Toma Vd. té o café ? 11. Tomo café con leche, gracias.

(II) 1. Aprende idiomas extranjeros. 2. Ese caballo corre muy de prisa (or, better, mucho). 3. ¿ Come Vd. mucho pan ? 4. El tendero no vende mucho ahora. 5. ¿ No comprenden su explicación (de Vd) ? 6. Creo que no son ingleses. 7. ¿ Por qué no contestan ? 8. Porque temen las consecuencias. 9. Yo no prometo eso.

(III) 1. No vive acquí ahora. 2. ¿ Recibe Vd. noticias de América todas las semanas ? 3. ¿ Por qué no admiten niños ? 4. No discutimos eso. 5. Los precios suben muy raremente en la primavera. 6. ¿ Qué decide Vd. ? 7. Nunca cumple sus promesas. 8. ¿ Quién reparte el dinero ? 9. Surtimos a varias casas europeas. 10. No asisto a todas sus reuniones.

LESSON 7

Another Lesson on Pronouns

We now pass to the future indicative of regular verbs, which is formed by adding to the *infinitive* of each conjugation the terminations *é, ás, á, emos, éis, án.* The terminations which form the imperative mood are given in the next Lesson.

FUTURE INDICATIVE OF THE VERB COMPRAR.

Singular.	*Plural.*
comprar-é, I shall buy	*comprar-emos*, we shall buy
comprar-ás	*comprar-éis*
comprar-á	*comprar-án*

Similarly:

Second Conjugation: *beber-é, beber-ás*, etc., I shall drink.

Third Conjugation: *cumplir-é, cumplir-ás*, etc., I shall fulfil.

The future indicative of *ser* and *estar*, being regular, is formed

in the same way: *ser-é, ser-ás*, etc., I shall be; *estar-é, estar-ás*, etc., I shall be.

Haber and *tener* form their future by affixing the above terminations to *habr-* and *tendr-*: *habr-é, habr-ás*, etc., I shall have; *tendr-é, tendr-ás*, etc., I shall have.

VOCABULARY.

to hand over	*entregar*	receipt	*recibo*
to cancel	*cancelar*	account	*cuenta*
to import	*importar*	tool	*herramienta*
to see	*ver*	traveller	*viajante*
to ship	*embarcar*	time	*tiempo*
to build	*construir*	cattle	*ganado*
to issue	*emitir*	Government	*Gobierno*
to mature	*vencer*	road	*carretera*
to translate	*traducir*	bridge	*puente*
to learn	*aprender*	one thousand	*mil*
share	*acción*	December	*Diciembre*
documents	*documentos*	then	*entonces*

United States	*Estados Unidos*
railway company	*compañía de ferrocarriles*
bill (of exchange)	*letra (de cambio)*

next month, *el mes que viene* (lit the month which is coming).

EXERCISE 1.

TRANSLATE INTO SPANISH. 1. He will hand over the receipts. 2. They will not cancel their account until the spring. 3. Will you import all the tools from the United States? 4. We shall not see the traveller this year. 5. Our agents will ship the cattle as soon as possible. 6. The Government will build new bridges and roads. 7. The railway company will issue one thousand shares. 8. Will you be there very early? 9. The bill will mature in December. 10. Who will translate those German documents? 11. I shall have more time next month.

Cases of Personal Pronouns.* The dative and accusative cases of personal pronouns have two forms, one of which is never preceded by a preposition, and the other always. Both forms are sometimes used in the same sentence (1) to increase the emphasis of the direct or indirect object of the verb, or (2) to avoid ambiguity when the pronouns happen to be the same for both genders, as is the case with the third person. The single

form must always be used ; the form with *a* can only be employed in connexion with the other, but never by itself. These forms are :

	Dative.	Accusative.
me, to me	*me, a mí*	*me, a mí*
thee, to thee	*te, a ti*	*te, a ti*
him, to him	*le, a él*	*le, lo, a él*
her, to her	*le, a ella*	*la, a ella*
us, to us	*nos, a nosotros*	*nos, a nosotros*
you, to you	*os, a vosotros*	*os, a vosotros*
them, to them	*les, a ellos*	*los, a ellos*
them, to them (f.)	*les, a ellas*	*las, a ellas*

The other cases of the declension of personal pronouns are formed by the words *mí, ti, él, ella, nosotros* (*as*), *vosotros* (*as*), *ellos, ellas,* preceded by the corresponding prepositions as in English : *de mí,* from me ; *contra ellos,* against them. "With me," "with thee" are always translated by *conmigo, contigo ;* "with him," "with her" are sometimes rendered by *consigo.*

Position of Pronouns, The pronouns *me, te, le, lo, la, nos, os, les, los, las,* called Conjunctive Personal Pronouns, are usually placed in front of the verb whose object they are : *yo lo envidio,* I envy him.

The pronouns corresponding to the polite forms, *Vd, Vds,* are those of the third person, the masculine or feminine forms being used according to the sex and number of the person or persons addressed : *yo le he hablado a Vd,* I have spoken to you ; *él las ha visto a Vds,* he has seen you (fem. pl.). *A Vd, a Vds* must always be added after the verb for the sake of clearness As all Spanish nouns are either masculine or feminine, the pronoun "it" and its plural "them" must be rendered by the words corresponding to "him," "her," "them," according to the gender and number of the substantive they stand for : *yo lo tengo,* have it ; *ella las compraba,* she used to buy them (fem.).

When two pronouns occur in a sentence as direct and indirect objects of the same verb, the indirect (dative) is invariably placed in front of the direct (accusative), and both precede the verb : *él me lo da,* he gives it to me.

When both pronouns belong to the third person, *se* is used instead of the dative, *le, les,* for the sake of euphony : *yo se lo he enviado,* I have sent it to him.

The word "it," meaning "that," is invariably translated by *lo : yo se lo he explicado,* I have explained it to him.

ANOTHER LESSON ON PRONOUNS

When *a él, a ella*, etc., are used in order to make the meaning of a sentence quite clear, these words are generally placed after the verb: *se lo hemos pagado a ella*, we have paid it to her.

In negative sentences personal pronouns are placed between the negative and the verb: *yo no los veo ahora*, I do not see them now.

When one or two pronouns are used in connexion with an infinitive or present participle, they form one word with the verb, to which they are affixed without altering the stress: *escribirles*, to write to them; *ofreciéndomelo*, offering it to me. Although the pronouns may also be affixed to other tenses, this construction is only met with in literature, never in ordinary conversation: *prestábaselo (a ellos) con frecuencia*, he used to lend it to them often.

VOCABULARY.

to bring	*traer*	to explain	*explicar*
to know	*saber*	to work	*trabajar*
to send	*enviar*	news	*noticias*
to check	*comprobar*	for	*para*
to wish	*desear*	every day	*todas los días*
to give	*dar*	where from ?	*¿ de dónde ?*
to lend	*prestar*	mother	*madre*
to speak	*hablar*	policeman	*policía*
to keep	*guardar*	at once	*enseguida*

every other day, *cada dos días*

EXERCISE II.

TRANSLATE INTO SPANISH. 1. We have no news from him. 2. Is that letter for me ? 3. He had it (f.). 4. Why have you not brought them ? 5. She did not know it. 6. When will you send us the account ? 7. I shall ship them at once. 8. The manager is writing to him, not to them. 9. Will the Government build it ? 10. They used to check them (f.) every other day. 11. We wish to see him. 12. Where do you import them from ? 13. You used to give it to her, but not to him. 14. Who has lent it to you ? 15. Her mother will not see her next month. 16. We were speaking to them. 17. Was it you who used to hand them over to them every day ? 18. Will they keep the shares or will they sell them ? 19. His friend used to work with me. 20. It will be easier to translate it here. 21. The policeman was explaining it to me.

Hours of the Day. These are expressed by placing the feminine article *la* in front of the word *una* for "one o'clock," and *las* in front of the cardinal numbers corresponding to the other hours. *Una*, and not *uno*, is used, because the omitted word *hora* is feminine but none of the other cardinal numbers have gender: *las ocho*, eight o'clock In sentences expressing time "it is," "it was," "it will be," and so on, are invariably rendered by *es*, *era*, *será*, and so on, in front of *la una*, and *son*, *eran*, *serán*, and so on, before any of the other hours

"Past" is invariably translated by *y* (and), and "to" by *menos* (less): *las seis menos cuarto*, a quarter to six; *las doce y cuarto*, a quarter past twelve, *las dos y media*, half-past two; *las tres menos diez*, ten minutes to three.

The cardinal numbers up to twelve are given in page 578.

13, *trece* 14, *catorce*. 15, *quince*. 16, *dieciseis*. 17. *diecisiete*, 18, *dieciocho*. 19, *diecinueve*. 20, *veinte*

VOCABULARY.

quarter	*cuarto*	half	*media*
minute	*minuto*	fast	*adelantado*
slow	*atrasado*	always	*siempre*
sharp	*en punto*	to end	*acabar*
week	*semana*	to tell	*decir*
watch	*reloj*	performance	*función*
the time	*la hora*	day	*día*
can you?	*¿ puede V ?*	soon after	*poco después*

with pleasure, *con mucho gusto*
what time is it? *¿ qué hora es ?*
the station clock, *el reloj de la estación*

EXERCISE III.

TRANSLATE INTO SPANISH. 1. Five o'clock. 2. Ten o'clock. 3. A quarter to two. 4. Half-past one. 5 It was five minutes to eleven. 6. It will be then three o'clock. 7 Sixteen minutes to ten. 8. What time is it? 9. It is four o'clock. 10. My watch is five minutes fast. 11. The station clock is always slow. 12. I shall be there at ten o'clock sharp. 13. A week has seven days, and a year twelve months. 14. Is it one o'clock already? 15. Not yet. 16. At what time is dinner? 17. Soon after seven. 18. At what time will the performance end? 19. At eight o'clock sharp. 20. Can you tell me the time? 21. With pleasure; it is ten to ten.

KEYS TO EXERCISES IN LESSON 6

(I) 1 ¿De quién es este sombrero? 2 Mío 3 ¿Ha vendido V sus géneros o los míos? 4 No he vendido ni los suyos ni los de V 5 ¿Es su casa (de V) más cara que la nuestra? 6 No sé pero creo que la nuestra es carísima 7 Sus temas son los más cortos pero son dificilísimos ¿Cómo son los de V? 8 Los míos son mas fáciles que los suyos 9 No es amigo mío 10 Una frase suya 11 Son felicísimos 12 Afirman que esas equivocaciones no son suyas

(II) 1 Cambiaba todos sus billetes en el correo 2 Escondía la llave 3 Alquilaba un automóvil todas las mañanas 4 Administraban la hacienda mientras el dueño estaba ausente 5 Los soldados estaban luchando en la cumbre de la montaña 6 La antigua casa gastaba mucho dinero en anuncios 7 No estaba en casa ese día 8 Había estado nevando toda la mañana

(III) 1 Comía con mis amigos ingleses 2 Su caballo corría más que el mío 3 Ella hacía mi trabajo cuando yo estaba en el Continente 4 ¿Era V él que llamaba a la puerta? 5 ¿Quién encendía el fuego en su cuarto (de V)? 6 Vendían a precios más bajos 7 Cosía mucho cuando era joven 8 Leíamos cuando llovía

(IV) 1 Escribíamos casi todas sus cartas 2 Los soldados dormían en el campamento 3 Abría todas las ventanas 4 Distribuían las ganancias entre los accionistas 5 Vivíamos cerca del río 6 ¿Quién era el tenedor de libros entonces? 7 No tenían agentes en París 8 Venía muy temprano 9 El profesor corregía sus temas 10 Recibíamos el correo al amanecer.

LESSON 8

Adverbs and the Imperative Mood

THE imperative mood is formed by adding the terminations *e*, *emos*, *en* to the stem of all regular verbs of the first conjugation, and *a*, *amos*, *an* to the stem of those of the second and third conjugations In the third persons, "let" is usually rendered by *que* "Him," "her," "them," "us," are hardly ever translated but the polite form is very seldom

omitted. The numbers in brackets (1), (2), (3), indicate the conjugations.

IMPERATIVE MOOD.

Singular.	*Plural.*
(1) *compr-e Vd*, buy	*compr-emos*, let us buy.
que compr-e, let him or her buy	*compr-en Vds*, buy
	que compr-en, let them buy.
(2) *beb-a Vd*, drink	*beb-amos*, let us drink
que beb-a, let him or her drink	*beb-an Vds*, drink
	que beb-an, let them drink.
(3) *cumpl-a Vd*, fulfil	*cumpl-amos*, let us fulfil
que cumpl-a, let him or her fulfil	*cumpl-an Vds*, fulfil.
	que cumpl-an, let them fulfil.

The familiar forms are: *compra, comprad; bebe, bebed; cumple, cumplid.* The negative imperative of the singular familiar form presents the anomaly of having a different ending from the positive: *no compres*, do not buy; *no bebas*, do not drink: *no cumplas*, do not fulfil.

THE VERBS SER, ESTAR AND TENER.
IMPERATIVE MOOD.

Singular.	*Plural.*
sea Vd, be	*seamos*, let us be
que sea	*sean Vds*
	que sean
esté Vd, be	*estemos*, let us be
que esté	*estén Vds*
	que estén
tenga Vd, have	*tengamos*, let us have
que tenga	*tengan Vds*
	que tengan

In positive sentences the object pronouns follow the imperative, but in negative phrases they are placed in front of the verb: *comprémoslos*, let us buy them; *no lo beba Vd*, do not drink it. When the indirect pronoun *se* is affixed to the first person plural of the imperative the final *s* of the verb should be omitted: *enviémoselo*, let us send it to her.

When the word "let" means "permit," it must be rendered by the imperative mood of the verb *dejar*: *déjela Vd escribir*, let her write. In such sentences the second verb is frequently

used in the corresponding person of the imperative: *déjelos Vd que hablen*, let them speak.

"Please" is rendered by *haga Vd el favor de* (lit., Do me the favour of). The verb following the preposition *de* must be in the infinitive: *haga Vd el favor de darme aquel sobre*, please give me that envelope

VOCABULARY.

to sing	*cantar*	to wait for	*esperar*
to ask	*preguntar*	to practise	*practicar*
debt	*deuda*	to forget	*olvidar*
ready	*listo*	to pardon	*perdonar*
cable	*cable*	to excuse	*dispensar*
word	*palabra*	good-bye	*adiós*
per month	*al mes*	by heart	*de memoria*
so fast	*tan de prisa*	confidence	*confianza*
to type	*escribir a máquina*	cab-rank	*parada de coches*
how much ?	*¿ cuánto ?*	relation	*pariente*
free on board	*franco a bordo*	the nearest	*la más próxima*
dollar	*peso*	impatient	*impaciente*

sometimes, *algunas veces*; something else, *otra cosa*; for the present, *por ahora*.

NOTE. *La más próxima* is the fem. form. The masc. is *el más próximo*, and the neuter is *lo más próximo*.

EXERCISE 1.

TRANSLATE INTO ENGLISH: 1. Guardémosla. 2. Véndaselos Vd a ella. 3. Que lo escriban a máquina. 4 No se lo preste Vd. 5. Que lo aprenda de memoria. 6. No hablen Vds tan de prisa. 7. Déjelo Vd hablar. 8. No lo compre Vd en esa tienda. 9. Déjela Vd que cante. 10. Preguntemos. 11. Que no las firmen todavía. 12. Perdóneme Vd (*or* Vd perdone).

Exceptional Imperatives. A number of verbs have irregular imperatives. The following should be remembered:

	Singular.	*Plural.*
to explain, *explicar*	*explique*	*expliquemos*
check, *comprobar*	*compruebe*	*comprobemos*
shut, *cerrar*	*cierre*	*cerremos*
think, *pensar*	*piense*	*pensemos*
try, *probar*	*pruebe*	*probemos*

	Singular.	Plural
look for, *buscar*	*busque*	*busquemos*
pay, *pagar*	*pague*	*paguemos*
begin, *comenzar*	*comience*	*comencemos*
bring, *traer*	*traiga*	*traigamos*
do, *hacer*	*haga*	*hagamos*
know, *saber*	*sepa*	*sepamos*
put, *poner*	*ponga*	*pongamos*
come back, *volver*	*vuelva*	*volvamos*
see, *ver*	*vea*	*veamos*
go, *ir*	*vaya*	*vayamos*
come, *venir*	*venga*	*vengamos*
repeat, *repetir*	*repita*	*repitamos*
tell, *decir*	*diga*	*digamos*
go out, *salir*	*salga*	*salgamos*
hear, *oir*	*oiga*	*oigamos*
order, *pedir*	*pida*	*pidamos*
choose, *elegir*	*elija*	*elijamos*
translate, *traducir*	*traduzca*	*traduzcamos*

EXERCISE II.

TRANSLATE INTO SPANISH: 1. Bring it to me. 2. Let us sell them to her. 3. Excuse me, where is the nearest cab-rank? 4. Ask (it) a policeman. 5. Do not let us order them yet. 6. Why not? 7. Because we have something else to do for the present. 8. Please type those two letters. 9. Let him go out. 10. Do not come before seven o'clock. 11. Please put this glass on my table. 12. Let them pay their debts. 13. Choose one.

Adverbs. Adverbs may be simple, derivative, or compound. Simple adverbs consist of a single word, as *antes*, before; *después*, afterwards. Derivative adverbs, which are formed in English by affixing the termination "ly" to the adjective, are formed in Spanish by adding *mente* to the feminine form of the radical adjective: *rápido*, quick; *rápidamente*, quickly. When the adjective has only one termination for both genders, *mente* is affixed to this ending: *hábil*, clever; *hábilmente*, cleverly. Compound adverbs are composed of two or more words: *a pesar de*, in spite of; *sin embargo*, however.

When several adverbs follow one another in the same sentence, *mente* is only added to the last: *enérgica pero noblemente*, firmly but nobly.

ADVERBS & THE IMPERATIVE MOOD

Although the position of the adverb in a sentence is to a certain extent quite optional, it generally follows the verb: *vivía entonces en Londres*, he was then living in London.

When the negative words *ni*, neither, nor; *ninguno*, none; *nadie*, nobody; *ninguna parte*, nowhere; *nunca, jamás*, never; *nada*, nothing, follow the verb, the adverb of negation *no* must be placed in front of the latter. When those words precede the verb, *no* is not required: *no le escribo nunca*, or *nunca le escribo*, I never write to him; *no viene nadie a ofrecernoslas ahora*, or *nadie viene a ofrecernoslas ahora*, nobody comes to offer them to us now.

The following important adverbs should be memorized:

down	*abajo*	then	*entonces*
perhaps	*acaso*	outside	*fuera*
besides	*además*	today	*hoy*
somewhat	*algo*	never	*jamás*
there	*allí*	far	*lejos*
scarcely, hardly	*apenas*	afterwards	*luego*
here	*aquí*	badly	*mal*
up	*arriba*	tomorrow	*mañana*
yesterday	*ayer*	less	*menos*
enough, rather	*bastante*	much	*mucho*
well	*bien*	very	*muy*
almost	*casi*	never	*nunca*
near	*cerca*	little	*poco*
how, as	*como*	perhaps	*quizás*
when	*cuando*	seldom	*raramente*
beneath	*debajo*	always	*siempre*
in front	*delante*	late	*tarde*
within	*dentro*	perhaps	*tal vez*
afterwards	*después*	so	*tan*
behind	*detrás*	early	*temprano*
above	*encima*	already	*ya*
opposite	*enfrente*	still, yet	*todavía*

EXERCISE III.

TRANSLATE INTO SPANISH: 1. Please send us the goods free on board. 2. How much used you to pay? 3. Fifteen dollars per month. 4. When will he explain it to them? 5. He has already explained it to them. 6. Wait for me outside. 7. Does your partner know Spanish? 8. Very little, but he is studying

it now. 9. Does he practise with you sometimes? 10. No; he never tries to speak with me. 11. I used to speak it rather well, but I have almost forgotten it. 12. Will you go to the theatre tonight? 13. I do not think so; they always arrive too late. 14. Please tell me how you pronounce that word. 15. With much pleasure. 16. Where shall I see you afterwards? 17. I will be here within (of) an hour.

KEYS TO EXERCISES IN LESSON 7.

(I). 1. Entregará los recibos. 2. No cancelarán su cuenta hasta la primavera. 3. ¿ Importará Vd todas las herramientas de los Estados Unidos? 4. No veremos al viajante este año. 5. Nuestros agentes embarcarán el ganado lo antes posible. 6. El Gobierno construirá nuevos puentes y carreteras. 7. La compañía de ferrocarriles emitirá mil acciones. 8. ¿ Estará Vd allí muy temprano? 9. La letra vencerá en Diciembre. 10. ¿ Quién traducirá esos documentos alemanes? 11. Tendré más tiempo el mes que viene.

(II) 1. No tenemos noticias de él. 2. ¿ Es esa carta para mí? 3. La tenía (La tenía *él*). 4. ¿ Por qué no los ha traido Vd? 5. Ella no lo sabía. 6. ¿ Cuándo nos enviará Vd la cuenta? 7. Los embarcaré enseguida. 8. El jefe está escribiéndole a él, no a ellos. 9. ¿ Lo construirá el Gobierno? 10. Las comprobaban cada dos días. 11. Deseamos verlo. 12. ¿ De dónde los importa Vd? 13. Vd se lo daba a ella pero no a él. 14. ¿ Quién se lo ha prestado a Vd? 15. Su madre no la verá el mes que viene. 16. Estábamos hablándoles 17. ¿ Era V. él que se los entregaba todos los días? 18. ¿ Guardarán las acciones o las venderán? 19. Su amigo trabajaba conmigo. 20. Será más fácil traducirlo aquí. 21. El policía estaba explicándomelo (*or* me lo estaba explicando).

(III). 1. Las cinco. 2. Las diez. 3. Las dos menos cuarto. 4. La una y media. 5. Eran las once menos cinco (minutos). 6. Serán entonces las tres. 7. Las diez menos dieciseis. 8. ¿ Qué hora es? 9. Son las cuatro. 10. Mi reloj está cinco minutos adelantado. 11. El reloj de la estación está siempre atrasado. 12. Estaré allí a las diez en punto. 13. Una semana tiene siete días y un año doce meses. 14. ¿ Es ya la una? 15. Todavía no. 16. ¿ A qué hora es la comida? 17. Poco después de las siete. 18. ¿ A qué hora terminará la función? 19. A las ocho en punto. 20. ¿ Puede Vd decirme la hora? 21. Con mucho gusto; son las diez menos diez.

LESSON 9

A Lesson on Numbers

THE past definite of regular verbs is formed by adding to the stem of verbs of the first conjugation the terminations, *é*, *aste*, *ó*, *amos*, *asteis*, *aron* ; and to the stems of verbs of the second and third conjugations the terminations *í*, *iste*, *ió* *imos*, *isteis*, *ieron*.

PAST DEFINITE.

Singular.

I bought	I drank	I fulfilled
compr-é	*beb-í*	*cumpl-í*
compr-aste	*beb-iste*	*cumpl-iste*
compr-ó	*beb-ió*	*cumpl-ió*

Plural.

compr-amos	*beb-imos*	*cumpl-imos*
compr-asteis	*beb-isteis*	*cumpl-isteis*
compr-aron	*beb-ieron*	*cumpl-ieron*

The past definites of (1) *ser*, (2) *estar*, (3) *tener*, and (4) *haber* are irregularly formed, and run as follow :

Singular.

(1) I was	(2) I was	(3) I had	(4) I had
fuí	*estuve*	*tuve*	*hube*
fuiste	*estuviste*	*tuviste*	*hubiste*
fué	*estuvo*	*tuvo*	*hubo*

Plural.

fuimos	*estuvimos*	*tuvimos*	*hubimos*
fuisteis	*estuvisteis*	*tuvisteis*	*hubisteis*
fueron	*estuvieron*	*tuvieron*	*hubieron*

VOCABULARY

to cost	*costar*	all	*todo*
to take	*tomar*	the last	*el último*
to greet	*saludar*	contractor	*contratista* (m.)
to agree	*acordar*	Christmas	*Pascua*

to travel	*viajar*	the night	*la noche*
to last	*durar*	a journey	*un viaje*
regiment	*regimiento*	bay	*bahía*
about	*respecto a*	battle	*batalla*
fortress	*fortaleza*	soon after	*poco después*
according to	*según*	the wharf	*el muelle*
by storm	*por asalto*	a song	*una canción*
a couple of	*un par de*	at least	*por lo menos*

how long ?	*¿ cuánto tiempo ?*
later than ever	*más tarde que nunca*
a return ticket	*un billete de ida y vuelta*
in the middle of	*en medio de*
to cast anchor	*anclar*
as far as	*hasta*

EXERCISE I.

TRANSLATE INTO SPANISH 1. Did you understand the song ? 2 No ; she sang in Italian that night. 3. We waited at least two hours. At what time did the train arrive ? 4. Later than ever. Nearly at half-past eight. 5. How much did the journey cost you ? 6. I took a return ticket, which is much cheaper. 7. When did the contractors begin to build the wharf ? 8. I think they began soon after Christmas 9. Did you check all the invoices ? 10. No ; I had no time to check them all. 11. Did it rain ? 12. Only in the evening. 13. Did they wait at home ? 14. No ; they went out to greet him. 15 Where did the steamer cast anchor ? 16. In the middle of the bay. 17. I do not understand why they did not answer my telegram at once.

Cardinal Numbers. These numbers are as follow :

0	*cero*	11	*once*	22	*veintidos*
1	*uno*	12	*doce*	23	*veintitres*, etc.
2	*dos*	13	*trece*	30	*treinta*
3	*tres*	14	*catorce*	31	*treinta y uno*
4	*cuatro*	15	*quince*	32	*treinta y dos*
5	*cinco*	16	*dieciseis*	33	*trienta y tres*, etc.
6	*seis*	17	*diecisiete*	40	*cuarenta*
7	*siete*	18	*dieciocho*	50	*cincuenta*
8	*ocho*	19	*diecinueve*	60	*sesenta*
9	*nueve*	20	*veinte*	70	*setenta*
10	*diez*	21	*veintiuno*	80	*ochenta*

90	*noventa*	700	*setecientos*
100	*cien, ciento*	800	*ochocientos*
101	*ciento uno*	900	*novecientos*
102	*ciento dos*, etc.	1,000	*mil*
200	*doscientos*	2,000	*dos mil*, etc.
300	*trescientos*	100,000	*cienmil*
400	*cuatrocientos*	1,000,000	*un millón*
500	*quinientos*	2,000,000	*dos millones*
600	*seiscientos*	100,000,000	*cien millones*

The cardinal numbers have no gender except *uno* and *doscientos, trescientos*, etc., which change the final *o* into *a* before a feminine substantive.— *dos libros*, two books ; *dos casas*, two houses ; but *doscientos soldados*, 200 soldiers ; *doscientas enfermeras*, 200 nurses.

Uno and *ciento* in front of a noun or adjective are contracted to *un* and *cien* respectively—*un peso*, one dollar ; *cien caballos blancos*, one hundred white horses.

Tens of hundreds cannot be used in reading Spanish figures. Therefore the numbers 1100, 1200, 1300, etc., must be invariably rendered by *mil ciento, mil doscientos, mil trescientos*, etc.

The preposition *de* is always added to the word *millón* and its plural *millones* when the substantive immediately follows—*dos millones de francos*, 2,000,000 francs. Before *ciento* and *mil* the word *un* is never used, but 1,000,000 is invariably read as *un millón*.

The age of a person is expressed by " to have years," instead of " to be old." The question " How old is she ? " is therefore rendered by " *¿ Cuántos años tiene ella ?* " (literally, " How many years has she ? ") " She is twenty-two " should be translated accordingly by " *Tiene veintidos años.*" The question may also be put in this manner : " *¿ Qué edad tiene ?* " (lit., " What age has she ? ").

VOCABULARY.

to command	*mandar*	killed	*muerto*
a shilling	*un chelin*	wounded	*herido*
to amount	*ascender*	prisoner	*prisionero*
the page	*la página*	customs	*aduanas*
to discover	*descubrir*	the area	*el área* (f.)
a pound	*una libra*	Columbus	*Colón*

to estimate	*calcular*	the enemy	*el enemigo*
the mine	*la mina*	the losses	*las bajas*
a gun	*un cañón*	a ship	*un buque*
a frigate	*una fragata*	Europe	*Europa*
annual	*anual*	between	*entre*
production	*producción*	equivalent	*equivalente*

a case of sugar	*una caja de azúcar*
land surface	*superficie territorial*
net receipt	*ingreso líquido*
square mile	*milla cuadrada*

EXERCISE II.

TRANSLATE INTO SPANISH. 1. Twenty ships. 2. Fifty-three shillings. 3. Seventy-nine pages. 4. Forty-five cases of sugar. 5 One hundred and seven pounds. 6. Three hundred and sixty-five days. 7. Six hundred and thirteen trees. 8. How old is he now? 9. He is seventy-five years old. At (trans. at the) twenty-three years of age he commanded a frigate of eighty-four guns. 10. What age were (imperfect) you then? 11. I was fifteen years old. 12. In 1700 Davenant estimated the annual production of all the mines of England (at) between seven and eight hundred thousand pounds. 13. The area of Canada is 3,510,000 square miles, which is nearly equivalent to the land surface of Europe. 14. The enemy's losses were 1050 men killed, 1700 wounded, and 2500 prisoners. 15. In 1844 the net receipt of the Customs at (trans. *de*) Liverpool amounted to £4,365,526 1s. 8d.

Ordinal Numbers. The ordinal numbers agree in gender and number with the following noun and are as follow:

1st *primero*	13th *décimo tercio*
2nd *segundo*	14th *décimo cuarto*, etc.
3rd *tercero*	20th *vigésimo*
4th *cuarto*	21st *vigésimo primo*
5th *quinto*	22nd *vigésimo segundo*
6th *sexto*	30th *trigésimo*
7th *séptimo*	40th *cuadragésimo*
8th *octavo*	50th *quincuagésimo*
9th *noveno, nono*	60th *sexagésimo*
10th *décimo*	70th *septuagésimo*
11th *undécimo*	80th *octagésimo*
12th *duodécimo*	90th *nonagésimo*

100th *centésimo.*

After "the tenth," cardinal numbers are generally used instead of the ordinal numbers—*el tomo quince*, the fifteenth volume; *el capítulo treinta*, the thirtieth chapter.

The days of the month, which in English are expressed by ordinals, are rendered in Spanish by the corresponding cardinal numbers, with the only exception of "the first," which is nearly always translated by *el primero*—*el 17 de Enero*, the 17th (lit. seventeen) of January; *el 8 Junio*, the 8th of June.

Ordinals may be placed before or after the noun they qualify, but the cardinal numbers must always follow the substantive; thus, the second lesson, *la segunda lección*, or *la lección segunda*, but "the 25th lesson" must be rendered by *la lección veinticinco*.

Whenever the masculine ordinal numbers *primero* and *tercero* are placed in front of the masculine noun the final *o* must be dropped—*el primer capítulo*, the first chapter, but *el capítulo primero*.

With the names of kings, popes, and the like the ordinals must be used up to the 10th. Beyond this figure the cardinal numbers are commonly employed and the article is invariably omitted; thus, Edward VII, *Eduardo Séptimo*; Alphonse XIII, *Alfonso Trece*.

Fractions. "One half" and "one third" are respectively rendered by *la mitad* or *un medio*, and *un tercio*. From $\frac{1}{4}$ up to $\frac{1}{10}$, fractional numbers are expressed by ordinals, but beyond $\frac{1}{10}$ the terminations *avo, avos* must be affixed to the corresponding cardinal numbers; *dos quintos*, $\frac{2}{5}$; *cinco catorceavos*, $\frac{5}{14}$; *un veintinueveavo*, $\frac{1}{29}$. The decimal units 0.01, 0.001, 0.0001, and so on, are rendered by *una centésima, una milésima, una diezmilésima*; *tres milésimas*, .003.

The most important numerical substantives and adjectives are the following:

a couple	*un par*	fourfold	*cuádruplo*
ten	*una decena*	fivefold	*quíntuplo*
a dozen	*una docena*	sixfold	*séxtuplo*
a thousand	*un millar*	tenfold	*décuplo*
double	*doble*	hundredfold	*céntuplo*
threefold	*triple*	manifold	*múltiple*

a hundred, *una centena* or *un centenar*

NOTE. 5, 6, 10, and 100 fold take the feminine gender also.

VOCABULARY.

to land	*desembarcar*	the class	*la clase*
to be born	*nacer*	a building	*un edificio*
to ascend	*ascender*	the floor	*el piso*
to expire	*expirar*	the library	*la biblioteca*
to contain	*contener*	a volume	*un tomo*
to remain	*permanecer*	chapter	*un capítulo*
same	*mismo*	the wife	*la esposa*
exclusive	*exclusivo*	the date	*la fecha*
Spain	*España*	a port	*un puerto*
England	*Inglaterra*	the tonnage	*el arqueo*
Italy	*Italia*	a ton	*una tonelada*
Charles	*Carlos*	the vessel	*el barco*
the king	*el rey*	stationary	*estacionario*
the pope	*el papa*	the right	*el derecho*
the throne	*el trono*	a quarter	*un cuarto*
a kingdom	*un reino*	per	*por*
the reign	*el reinado*	an inch	*una pulgada*
a century	*un siglo*	at the close	*al final*
foot	*pie*	the birth	*el nacimiento*

the New World	*el Nuevo Mundo*
without reckoning	*sin contar*
the birthday	*el cumpleaños*
the population	*la población*
the rate	*la proporción*
an emperor	*un emperador*
the inhabitant	*el habitante*
not a single provincial town	*ni una sola ciudad provinciana*

EXERCISE III.

TRANSLATE INTO SPANISH. 1. He smokes a couple of pipes after dinner. 2. I used to travel (in) third class. 3. They are living now on the fifth floor of the same building. 4. I read it in the first chapter. 5. Did you lend him the 20th volume of the Spanish library? 6. We landed at Valparaiso on the 21st of December (of), 1879. 7. His wife was born on the 6th of January, 1886. 8. August the 30th will be her first son's birthday. 9. What date is today? 10. The 19th of February. 11. Philip III ascended (to) the throne of Spain in 1598. 12. In 1493 the Pope Alexander VI granted to the Catholic kings exclusive rights over the New World. 13. The Emperor Charles V expired (on)

the 21st of September, 1558, at the age of 58 years 6 months and 25 days. 14. At the close of the 17th century the population of England was *(era)* 5,200,000 souls. 15. The tonnage of the steamers of the port of London amounted, at the close of 1854, to 138,000 tons, without reckoning vessels of less than fifty tons. 16. In the reign of Charles II, Macaulay writes, not a single provincial town in the (trans. *del*) kingdom contained (impf.) 30,000 inhabitants, and only four had (impf.) 10,000. 17. During a quarter of (a) century the rate of births in Italy remained almost stationary, at 37 per 1,000. 18. One inch is equal to 1-12th of (a) foot. 19. 0·04563.

KEYS TO EXERCISES IN LESSON 8.

(I). 1. Let us keep it. 2. Sell them to her. 3. Let them type it. 4. Do not lend it to him (*or* to her) 5. Let him learn it by heart. 6. Do not speak so fast 7. Let him speak. 8. Do not buy it in that shop 9. Let her sing. 10. Let us ask. 11. Let them not sing them yet. 12. Pardon me

(II). 1. Tráigamelo Vd. 2. Vendámoselos (a ella). 3. Dispense Vd., ¿ dónde está la parada de coches más próxima ? 4. Pregúnteselo Vd. a un policía. 5. No los pidamos todavía. 6. ¿ Por qué no ? 7. Por que tenemos otra cosa que hacer por ahora. 8. Haga el favor de escribir a máquina estas dos cartas. 9. Déjelo Vd. salir. 10. No venga Vd antes de las siete. 11. Haga Vd. el favor de poner este vaso en mi mesa. 12. Que paguen sus deudas. 13. Elija Vd. uno.

(III). 1. Haga Vd. el favor de enviarnos los géneros franco a bordo. 2. ¿ Cuánto pagaba Vd. ? 3. Quince pesoso al mes. 4. ¿ Cuándo se lo explicará (a ellos) ? 5. Ya se lo ha explicado. 6. Espéreme Vd. fuera. 7. ¿ Sabe su socio el español ? 8. Muy poco, pero lo está estudiando ahora. 9. ¿ Practica con Vd. algunas veces ? 10. No, nunca prueba a hablar conmigo. 11. Yo lo hablaba bastante bien pero casi lo he olvidado. 12. ¿ Irán Vds. al teatro esta noche ? 13. Creo que no ; siempre llegan demasiado tarde. 14. Haga Vd. el favor de decirme como pronuncia esa palabra. 15. Con mucho gusto. 16. ¿ Dónde veré a Vd. depués ? 17. Estaré aquí, dentro de una hora.

Our Course in Spanish is continued in Volume 5.

LESSON 16

Crabs and Allied Crustaceans

Of more than merely zoological interest are the *Crustacea*, because many members make important contributions to our food supply Crabs and lobsters, together with prawns and shrimps, serve Man directly as food, while minute and less familiar crustaceans like copepods—which form immense swarms in the surface layers of the sea—serve indirectly, forming as they do an important element in the food of fishes

Despite numerous variations in size and form, in structure, habit and coloration, members of the *Crustacea* are easily recognized by a number of common features The armour-plating of the body, so distinctive of the *Arthropoda* is highly charged with limy materials and forms a covering or crust enclosing the body The body is divided into segments, those of the head being fused together, while in the higher forms those of both head and thorax are likewise fused into a single mass, the *cephalothorax* Typically, however, three regions are seen and each of these bears characteristically forked limbs, though in some instances the outer branch of the fork has disappeared A difference from the insects and myriapods is the presence of two pairs of antennae borne on the head, the appendages of the second and third segments The most noteworthy difference between *Crustacea* and other arthropods, excepting *Limulus* is the possession of gills for respiratory purposes by the former

Limulus The King Crab. This interesting animal rightly belongs to the *Arachnida*, but this is a favourable point at which to examine its structure The animal lives in shallow water on the western shores of the North Atlantic and Pacific It is the last survivor of a waning group, and shows many structural features of an arachnid nature The front part of the body (head and thorax) is covered by a strong semicircular shield or carapace, on the upper side of which the eyes are situated This region bears six pairs of limbs corresponding to the chelicerae, pedipalps and walking legs of a spider or scorpion The bases of the limbs, however, surround an elongated mouth and are roughened to serve as grinding jaws (*gnathobases*)

The abdominal segments are also fused together, protected by a shield above, and bear a tail-spine, which serves to right the animal if accidentally turned on its back. The hinder appendages of this region, of which there are five pairs, are thin flattened plates to which the gills are attached. Each appendage is forked like a typical crustacean limb, the gills (or gill-books, as they are more correctly called) being about two hundred leaflets projecting from the outer branch.

Crustacean Evolution. The appendages of *Crustacea* are curiously modified to perform several different functions, and the nature of such modifications often affords a useful key to the evolution of the sub-phylum. In the lowest *Crustacea* or *Branchiopoda*—typified by the fairy shrimp, *Chirocephalus*—there lies behind the head a long series of trunk segments carrying appendages of similar form which perform three principal functions: they enable the animal to swim, to collect the minute organisms on which it feeds, and to breathe. They may, in addition, serve as sensory organs. The crustacean ancestor is visualized in some such form, that is to say, as possessing a long series of segments with uniform appendages.

In the more highly evolved *Crustacea* we see the results of specialization of such a series of appendages in many ways, but along five definite lines—which, incidentally, characterize the five classes of the sub-phylum. The members of these classes are thus considered to be derived from the ancestral type by modification along these lines. We can take these five classes in order, starting with the most primitive and proceeding to the most specialized.

Branchiopoda. In this class only the head region has become specialized, the trunk limbs remaining simple leaf-like structures used for several purposes. The name of the class is derived from the nature of the limbs, which bear gills but are also used for swimming and for capturing food. One of the largest and most interesting members of the class, *Apus*, lives in stagnant water. It possesses a large head-shield, which covers the chief part of the body. The animal rows itself along on its back by means of the numerous leaf-like appendages, to which soft, pear-shaped gills are attached. *Chirocephalus*, the fairy shrimp, is about half an inch long, translucent and colourless, and appears from time to time in pools of water, moving incessantly in the same manner as does *Apus*. The movements of its limbs serve to sweep food

particles along a median gully between the bases of the limbs and into the mouth. Swimming movements are thus combined with feeding ones. *Chirocephalus* lacks the head-shield possessed by *Apus.* In the common water-flea, *Daphnia,* the head-shield takes the form of a compressed shell which encloses the trunk but not the head. In *Branchiopoda* like *Estheria*—a European but not a British species—the head-shield forms a bivalve shell with a hinge and closing muscle, which envelops both head and thorax.

Ostracoda. This class contains forms which resemble *Estheria* superficially, having a bivalve shell with hinge and muscle, though differing widely in other respects. Thus the number of trunk limbs has been reduced to two pairs (there are ten to almost thirty in the *Estheria* type). The *Ostracoda* have short bodies, and food is gathered not by the trunk appendages, as in *Branchiopoda,* but by the head appendages. This is the second trend in crustacean evolution ; the shifting of function of the thoracic limbs to the head limbs, with great reduction in number of limbs in the former region. The tail is reduced to an insignificant stump. *Ostracoda* are minute crustaceans found in both salt and fresh water.

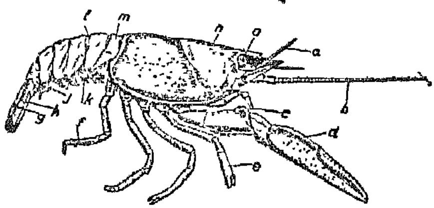
Copepoda. The members of this third class of crustaceans also feed by means of the head appendages, though the method in which these are used differs from that seen in the *Ostracoda.* There is no carapace and a trunk region of ten segments has been retained, of which the first six bear swimming limbs. The hinder part of the trunk has no appendages, and the segments of this region in some members are fused into a short stump.

Copepods form a very important class of food organisms in the sea, and constitute valuable links in food-chains, that is to say, series of animals the higher members of which feed upon the lower. They feed upon minute plants (diatoms) and in turn are preyed upon by other crustaceans and fishes. One species forms the food of herring, another species constitutes the bulk of the food of the Greenland or "right" whale. They are generally of microscopic size but produce abundant offspring, one female producing several million young animals in a year. So abundant are these animals that the sea is often coloured bright red by their tremendous swarms. Some of the members of the class have become degenerate parasites found adhering to the skin and gills of fishes, and are little more than egg-producing machines.

Cirripedia. This fourth class contains the familiar objects known as barnacles, animals which lead sedentary lives under the shelter of a large shield. They have forked limbs, which are used exclusively for procuring food organisms. Of the head appendages, the antennae have disappeared and the others are not used for feeding purposes. The thoracic limbs are long hairy filaments, used as sweep-nets. The tail is reduced and the body is fixed by the head end, well seen in the ship barnacle (*Lepas*) and the acorn barnacle (*Balanus*), which abounds on rocks between tide marks. In both instances the body is protected by shelly plates, but the head end of the ship barnacle is drawn out into a long fleshy stalk

Many near relatives of the barnacle are degenerate parasites, one of the most remarkable examples being *Sacculina,* of which the adult female is often found attached to the under side of the crab's tail. Dissection shows that *Sacculina* is provided with root-like branching threads, which ramify through the tissues of the unfortunate host and serve to absorb its blood and body fluids. The larva indicates the parasite's true affinity.

Malacostraca. This fifth class includes the highest *Crustacea* and is typified by lobsters and crabs, but also contains sand-hoppers and woodlice, of which the latter have become adapted to life on land. Lobsters and crabs are "ten-footed," crustaceans (*Decapoda*), so called because there are ten obvious limbs — the two great pincers and four pairs of walking legs. Twenty segments are comprised in the body, of which five, eight and seven belong to head, thorax and abdomen respectively. Head and thorax are fused together and form a head-thorax (*cephalothorax*), roofed over by a strong carapace. Limbs are borne on all three regions of the body and are typically forked, though in many instances the outer branch of the fork has been lost. The abdominal limbs are forked paddles known as *swimmerets,* best seen in large-tailed



COMMON CRAYFISH. Side view of Astacus, fluviatilis. a, antennule; b, antenna; c, third maxilliped; d, chela; e, first walking leg; f, fourth walking leg; g, telson. h, last appendage,; j, last segment of abdomen. k, swimmerets, l, abdomen; m, first segment of abdomen. n, carapace; o, eye.

From Borradaile, "The Invertebrata"

Decapoda like lobsters, cray-fishes and prawns. In such animals the tail is used as a swimming organ, its powerful downward movement propelling the animal tail foremost. In short-tailed *Decapoda* like the crab, the swimming habit has been abandoned for a creeping one. Head and thorax are enormously broadened, while the greatly reduced and insignificant tail is tucked up on the under side of the thorax.

The first two head segments bear each a pair of jaws. The hinder pair are large and relatively long. They are chiefly concerned with touch and constantly describe sweeping movements. The smaller first antennae are forked and have to do with both touch and smell, while an open sac is lodged in the base of each and assists in maintaining the balance of the body. The last three of the head segments bear jaws named, from before backwards, mandibles and first and second maxillae. The mandibles and first maxillae have lost the outer branch of the biramous limb, and the former are extremely powerful. An oval plate is attached to the second maxilla and lies in front of the gill cavity, a chamber under the sides of the carapace containing the delicate gills. This plate serves as a baling organ, its movement ensuring that a continuous current of water with dissolved oxygen shall move over the gill lamellae. The first three segments of the thorax have appendages known as foot-jaws or maxillipeds. Jaws and foot-jaws alike move from side to side and help to break up food. These structures are supplemented by a complex chewing arrangement contained within the stomach.

The lobster has stalked eyes. Some *Crustacea* have eyes devoid of stalks and are known as sessile-eyed crustaceans. They are much smaller than the stalked-eyed forms, and only the front segment of the thorax is fused with the head. There is but a single pair of foot-jaws, and the eggs are sheltered in a broad chamber on the under side of the thorax. This group includes sandhoppers and their allies, and slaters. Sandhoppers have a strongly bent body which is greatly flattened from side to side. This not only promotes swimming but also springing, the latter movement being particularly noticeable in the common sandhopper of our coasts. Slaters are creeping forms greatly flattened from above downwards, an adaptation to life in chinks and crevices. The shore slater, *Ligia*, is found just above tide marks in most parts of the world, but the most familiar crustacean of this kind is *Oniscus*, the land slater or woodlouse.

LESSON 17

Snails, Shell-Fish and Other Mollusca

THERE is one phylum of invertebrate animals which includes a number of apparently diverse creatures readily distinguished from the Arthropoda because their bodies are not divided into segments provided with limbs, but are commonly protected by a conspicuous calcareous shell. This phylum is the *Mollusca.* The under side of the body of the mollusc is thickened to form a muscular projection, the "foot," by which locomotion is effected. In most molluscs there is a well-developed head, though in some this region is not distinct. The *Mollusca* is one of the chief divisions of the animal kingdom and, like the Arthropoda, contains many very highly specialized members. The phylum is divided up into five classes, each with many well-known representatives: (1) *Amphineura,* which contains the chitons; (2) *Gastropoda,* including snails and slugs, whelks, periwinkles and other univalve (one-valved) "shell-fish"; (3) *Lamellibranchiata,* including the bivalve (two-valved) "shell-fish," such as mussels, cockles and oysters; (4) *Scaphopoda,* represented by the so-called "tusk-shells"; (5) *Cephalopoda,* including the cuttle-fishes, squids and the octopus, as well as the interesting pearly nautilus.

Lamellibranchiata, The most obvious character of this class is the possession of an external limy shell made up of two pieces or valves placed on right and left sides of the body. They are connected together on the upper side by an elastic ligament, which causes the shell to open or "gape" when its action is unopposed, as in the empty shell. Along the inner side of the hinge of the shell are often interlocking teeth and sockets, which serve to prevent displacement when the shell is opened or closed. Two fleshy bands (in some forms only one) stretch across from one valve to the other near the front and hind ends of the shell; these are the *adductor* muscles, by the contraction of which the shell is closed. It is the adductor muscle which the eater of oysters slices through in opening the oyster shell.

If we cut through the adductors of a bivalve mollusc like *Anodonta,* the fresh-water mussel, we find that each valve is

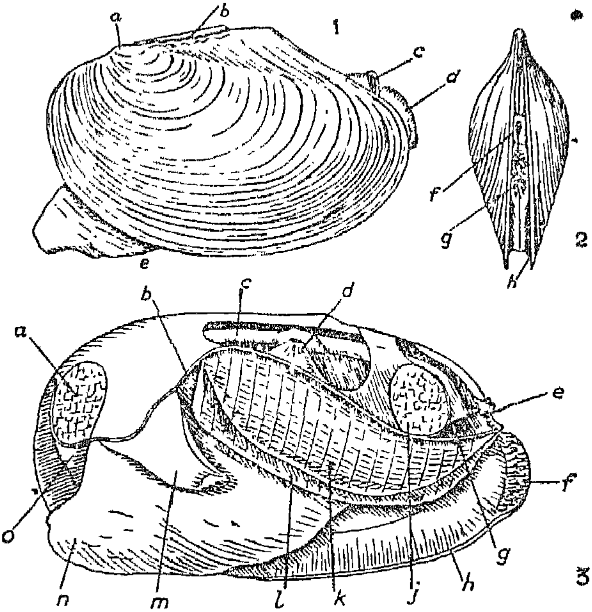
lined by a soft flap of the body wall, which is the *mantle*, the chief agent of shell formation As the animal grows the shell is made correspondingly larger by additions at its rim, which additions are laid down by the mantle edge. Thus we have the lines of growth—points at which one addition follows another—encircling the *umbo* or beak of the shell, which is the oldest part and which is usually found nearer the front end of the animal The pearly or nacreous inner surface of the shell is formed by the entire outer surface of the mantle.

On raising the mantle flap of one side we see below it the complicated plate-like gills from which the class derives its name—two laminae on each side, one lying on the inner side of the other. Each is really a double structure which hangs bag-like from the lower surface of the body The gills or *ctenidia* present a very complicated appearance under the microscope, consisting of a lattice work of fine filaments bearing ciliated cells The action of the cilia sweeps a steady stream of water through the lattice work and into the cavity of the lamella from the cavity between the mantle lobes. This stream of water passes into a large chamber lying above the ctenidia and thence to the exterior by a small tube, the *exhalant siphon*, seen at the hinder end of the animal between the valves of the shell The stream is maintained by the entrance of water through another tube, the *inhalant siphon*, lying immediately below the exhalant siphon. This water carries oxygen in solution and, since the gills are thin and richly vascularized, gaseous exchanges take place in their capillaries. But the principal organ of respiration is the mantle fold, which is also abundantly supplied with blood vessels and is constantly bathed in oxygen-containing sea water.

The water circulation through the body of the mussel serves another important function. Contained in it are minute organisms which constitute the food of the mussel. These are entangled in sticky mucous threads secreted by some of the cells of the gill-lamellae, and are waited by the action of special cilia towards the front end of the animal, where the mouth is situated. The ctenidia are specially modified feeding organs. When the train of particles reaches the anterior end of the animal, it is caught up by one or other of the two triangular flaps which lie on either side of the mouth. These flaps or *labial palps* are also ciliated, and serve to pass on the food train to the mouth.

Projecting between the lamellae of the ctenidia is the large

orange-coloured foot shaped like an axe-head and projecting to the front. This is the organ of locomotion. When blood is pumped into it, it is stretched forward, and then by contraction of its muscle fibres a shortening is effected by which the body is dragged along over the surface of the mud of the pond floor. The foot also contains several coils of the intestine, which communicates in front with a capacious stomach embedded in darkly



ANODONTA, 1. Entire animal from the left side; 2. from the hinder end; a, umbo; b, ligament; c and f, exhalant siphon; d and g, inhalant siphon; e, foot; h, mantle. 3. Animal with most of left mantle lobe removed; a, front adductor muscle; b, cut edge of left mantle lobe; c, hind part of intestine; d, heart; e, exhalant siphon; f, inhalant siphon; g, anus; h, right mantle lobe; j, hind adductor muscle; k, left external gill lamina; l, left internal gill lamina; m, labial palp; n, foot; o, mouth.
From Parker & Haswell, "Zoology," Macmillan

coloured digestive glands, and which opens to the exterior behind by way of the exhalant siphon, strangely enough, after passing through the substance of the heart. The reproductive glands are also lodged in the foot.

There are many bivalves in which the siphons are greatly elongated. Such a bivalve can remain sheltered in its vertical

burrow in sand or mud, and while its siphons reach the surface it is able to feed and respire in comfort. The ends of the siphon are pigmented and sensitive to changes of light intensity. Should a shadow fall upon them they are drawn in, and the animal burrows to avoid the danger which may threaten it. Some bivalves burrow more rapidly than others, the best burrowers possessing a long narrow shell with the foot projecting in front. *Solen*, the razor-shell, has these characters well marked. Some species are able to bore through wood or stone, the body twisting on its long axis, while the roughened front end of the shell is brought to bear on the structure to be bored through. Date shells (*Lithodomus*) and piddocks (*Pholas*) are good examples. The most notorious wood borer, however, is the so-called ship worm, *Teredo*, which at one time played havoc with the timbers of ships and piers.

Many bivalves have adopted easy-going lives, becoming temporarily or permanently fixed when adult. The edible mussel, *Mytilus edulis*, moors itself to fixed objects by black silky threads (the *byssus*). If conditions become unfavourable it can cast its moorings and seek a new home, though the small size of its foot indicates that it has ceased to lead an active life. In the scallop, *Pecten*, on the other hand, the foot is reduced to a useless vestige and the shell has become rounded in outline. The animal lies on its right side, having two dissimilar valves, but is by no means altogether sedentary; it can swim with an exquisite butterfly-like motion by the flapping action of the valves of its shell when occasion demands. The most typical example of a fixed bivalve is the oyster, which has entirely lost its foot and which, like *Pecten*, has only one adductor muscle. The animal is fixed by the substance of the thick and deeply concave left valve, lying below, while the right valve serves as a kind of lid, which can be raised for the admission of water currents.

Gastropods. In a typical Gastropod like the snail the shell is of spiral form, and the body of the animal is withdrawn into it as a means of defence. The under side of the foot is a flat sole-like expansion, from which a slime exudes, and by waves of muscular contraction the animal is able to glide along a smooth surface, as the most casual observer of our garden pest must have observed. The mouth is provided with a peculiar rasping organ, by which particles are scraped from the food object. It consists of a projection rising up from the floor of the mouth, over which

is stretched from front to back a horny ribbon, the *radula*, studded with rows of minute teeth, by which the rasping is effected.

Many snails live in the sea, and most of these respire by means of a plume-like gill situated in a cavity placed far forward on the upper side of the body and roofed by a membrane, the mantle, which helps to form the shell. As in bivalves, the purified blood flows into a two-chambered heart, which pumps it through the body in definite vessels. Some sea snails are purely vegetarian, others are carnivorous and highly predacious. There is a ready means of identifying the two kinds. In the former—the periwinkle, *Littorina littorea*, for instance—the opening of the shell is bounded by a continuous curve, and is said to be "entire." In carnivorous types there is in the shell edge a notch or canal which carries a siphon for conducting pure water to the gill chamber. Some carnivorous types prey upon other shell-fish, using their rasping organs for boring through the hard covering—a procedure sometimes assisted by acid secretions which tend to dissolve the limy shell.

Many sea snails have given up a creeping mode of life and have taken to swimming at or near the surface, with much modification in structure. *Carinaria* has part of the foot modified into a flattened fin, which moves from side to side and propels the animal as it floats on its back. The shell has become reduced to a small cap, which still serves to protect some of the more delicate organs of the body. The Pteropods or sea-butterflies are still more profoundly modified, having a pair of delicate muscular fins by means of which fluttering movements are effected. They may possess delicate glassy shells. These creatures are so abundant in the surface waters of the sea that, though extremely minute, they form an important item in the diet of the whalebone whale.

Land snails have probably descended from aquatic ancestors, but have lost their gills and have converted the gill chamber into an organ for breathing air, a sort of lung. Some of the lung-snails have taken to living in fresh water, and when these are kept in aquaria they may be seen to come to the surface from time to time to obtain air. The common pond snail, *Limnaea*, is a familiar form often seen crawling shell downwards along the surface film where air and water meet.

Scaphopoda. This is a small class of burrowing marine molluscs, in which the body is covered with a long curved shell

resembling a tusk in shape. At the tip of the shell is a small opening, through which the water that has been used in respiration makes its exit. The imperfectly developed head is furnished with a rasping organ, and burrowing is achieved by the use of a long foot with a three-lobed extremity. Food, which consists of small organisms, is secured by the agency of a bunch of filaments with swollen and adhesive tips that can be protruded from the mouth of the shell. Gills are absent and respiration takes place by means of the mantle. In some respects these animals are intermediate between typical sea snails and bivalves.

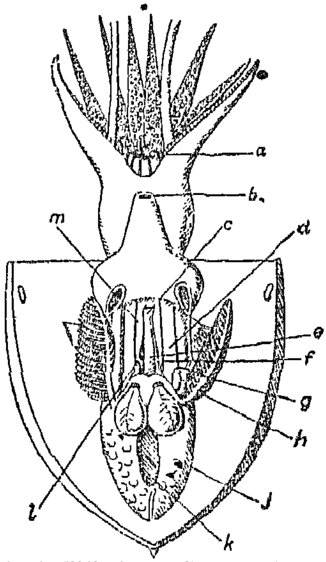
LESSON 18

Cuttlefishes, Squids and Oysters

Cuttlefishes, squids and octopods are highly predaceous and exclusively carnivorous members of the *Cephalopoda* which, living at a depth of a few fathoms in the sea, are often caught in the fisherman's trawl. These creatures are found commonly enough in our seas, but rarely reach a size at which they are dangerous to man , in other parts of the world, however, they grow to enormous sizes, and are a menace to the diver engaged in the sponge or pearl industry. Some of the giant cuttlefish of the North Atlantic may attain a length of 40 feet or more and may weigh half a ton.

In striking contrast to the lamellibranch or the gastropod, the cephalopod possesses great strength and shows extreme rapidity of movement. Moreover, it possesses a pair of prominent eyes, set at the sides of the head, which in degree of complexity closely approach those of the fish. In this as in other characters the cephalopod is one of the most highly organized members of the Mollusca. The foot so highly characteristic of most molluscs has become modified almost beyond recognition, being wrapped round and fused with the head. This region is drawn out into a number of arms—eight in number in the octopus, with the addition of two greatly elongated arms or tentacles in the cuttlefish and the squid. The inner sides of the arms and the swollen ends of the tentacles are studded with numerous small suckers, which cling so tenaciously to prey that the arms may be torn away before releasing their hold.

The bag-like and muscular body of the cephalopod, which is supported by an elongated internal shell or "pen" of horny consistency, contains important organs, including ctenidia or gills and an "ink-gland." The mouth is found within the ring of arms and tentacles surrounded by a fleshy circular lip, which partly hides from view a pair of powerful horny jaws resembling the beak of the parrot. There is also a tongue which carries numerous fine hooked teeth. Below the head is a wide aperture through which water enters the mantle cavity, to bathe the ctenidia lying therein, and projecting from the body immediately below the head is a short tube, the funnel, through which water flows to the exterior again. In the living animal the funnel alternately opens and shuts, water being expelled rhythmically from the body, carrying away faeces from the intestine, waste gases from the blood and the products of the excretory and reproductive glands. The funnel also plays an important part in locomotion. When cruising leisurely the animal makes use of narrow fins running along the sides of the body and of gentle streams of water ejected from the backwardly turned tip of the funnel. But when alarmed the animal shoots out a strong jet of water which, meeting resistance from the water outside, propels the animal backwards with great rapidity. At the same time an inky fluid is discharged and forms a dark obscuring cloud under cover of which the cuttle escapes. This fluid is the secretion of a glandular bag, the ink sac, in which it is stored until required. The pigment



CUTTLEFISH. Sepia cultrata, female, seen from the lower and hinder side, the wall of the mantle-cavity divided along the middle line and the two flaps thus formed spread out so as to expose the contents: a, mouth; b, external opening of funnel; c, anal aperture with lateral appendages; d, neck muscles; e, rectum; f, left kidney aperture; g, oviduct; h, left ctenidium; j, ovary; k, ink-sac; l, ink-duct; m, digestive gland. *From Parker & Haswell, "A Text-book of Zoology," Macmillan & Co., Ltd.*

Sepia was prepared originally from the ink sacs of cuttlefishes known as *Sepia officinalis*.

The heart of the cuttlefish, like that of other molluscs, is three-chambered. Two of these chambers, the auricles, receive oxygenated blood from the ctenidia, while the third, the ventricle, propels it to various parts of the body along fine arteries. One artery supplies the head, another the hinder parts of the animal, and a third the ink sac. Blood is collected from the tissues of the body, where it has passed through minute vessels or capillaries, by a series of large vessels or veins, which convey it to the ctenidia for re-oxygenation. The activities of the animal are controlled by the action of a complex nervous system. As in other molluscs nerve cells are aggregated into ganglia, which in the cephalopod are large and closely clustered around the first part of the food canal, immediately below the mouth. From the ganglia nerves are given off to the eyes and arms, as well as to the viscera and to the other organs of special sense, of which the statocyst, or balancing organ, located in the head region, is the most important. Cephalopods are either male or female, and the sperm, and egg-producing organs (testes and ovaries) form a compact mass near the end of the animal farthest removed from the mouth. A remarkable feature of the male is the production of chitinous capsules or spermatophores filled with sperms, instead of isolated sperms. The organs of reproduction are rendered very complicated by certain accessories for storage and nourishment of the sperms and for the inclusion of food materials within the egg.

Pearly Nautilus. There is one existing member of the cuttle-fish class which differs in many ways from the rest, and may be regarded as the last survivor of a group once dominant but now almost extinct, a sort of living fossil. This is the pearly nautilus, an inhabitant of moderately shallow water near the shores and coral reefs of the South Pacific. The rounded body is covered by an elegant external shell of regular spiral form. A section through this reveals the fact that the older part is divided by partitions or septa into a series of curved chambers. The animal lives in the last-formed chamber, which is continually enlarged as the animal grows, a new partition being added from time to time. The older part of the shell is converted into a series of gas-filled chambers, which help to buoy up the animal and prevent the large shell from becoming too great an encumbrance. This device has not proved a great success, for all molluscs with a

chambered external shell of this type have long since become extinct, with this single exception.

The *Amphineura*, which comprise the chitons, were at one time grouped with the *Gastropoda*, but are now regarded as sufficiently distantly related to the snails to form a separate class. Its typical members (the chitons) are extremely sluggish limpet-like creatures with a shell built up of eight overlapping pieces. Other and simpler members of the class are devoid of a shell, have elongated worm-like bodies and are the most primitive representatives of the Mollusca. *Chiton* has a much flattened body with a broad foot, which is not only an organ of locomotion but also one of adhesion, enabling the animal when at rest to cling tenaciously to the surface of a rock, after the fashion of the limpet.

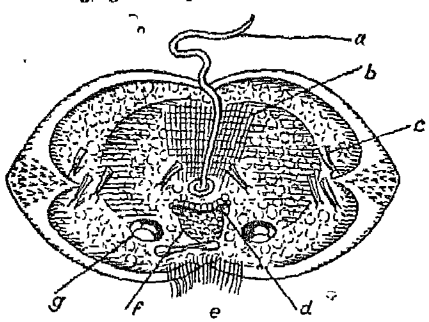
Cult of the Oyster. Oysters were deemed a delicacy even in the remotest times, and the culture of the oyster has become an important industry. The oysters of Whitstable were well known to the ancient Romans, who may be considered the pioneers of the industry. These molluscs thrive best where there is a certain admixture of fresh water with salt, as in estuaries. In order to secure a regular supply various methods of culture have been employed through the centuries, sometimes at a very primitive level, as in Italy, where the same methods are employed today as in classical times. In other countries, e.g. Holland and France, oyster culture has acquired a very elaborate technique. At the present time one of the greatest centres of oyster culture in the world is the Bay of Arcachon, south of Bordeaux.

All the marine bivalves commence life as minute free-swimming larvae, so that even fixed forms are able to reach fresh homes. The early larvae bear a remarkably close resemblance to the trochosphere of Annelida, and receive the same name. In the typical mollusc this early larva is followed by a second, which is characteristic of the Mollusca and is called a *veliger*. It possesses ciliated bands for locomotory and feeding purposes. The foot and shell are developed in this stage and, in the *Gasteropoda*, the latter develops its peculiar coil.

The larvae of the oyster are known as "fry," which after a period of free-living existence become transformed into "spat" and attach themselves to stones, shells and other firm objects. Arrangements for capturing the spat play a large part in oyster culture as practised at Arcachon. The natural oyster beds of France are carefully tended and preserved and serve as the

source of spat, the collection of which is the first concern of the industry. Special "collectors," in the form of crates of lime-washed earthenware tiles, are placed on the shore between tide marks. On these tiles the spat settle when free-swimming life is abandoned. The collectors are set down in early summer, and if there is a good "fall" of spat the tiles are soon covered with hundreds of minute specks, each of which is a potential oyster. The collectors are allowed to remain in the water until the early part of the following year, being carefully cleared of encrusting organisms meanwhile, and are then brought ashore for removal of the young animals.

By this time the spat have become transformed into minute "seed-oysters," which are flaked off the tiles and placed in shallow trays covered with wire gauze for further development. They are subsequently transferred to carefully prepared oyster beds, walled in, and provided with special flood gates for regulating the water supply. The oyster is not exported until it is two years old and roughly two inches in diameter. It is not eaten usually until it is four to five years old. The two-year-old animal is exported and sold to oyster fattening farms, of which those near Marennes are the most famous. Here the culture includes fattening, greening and education for transport. The first and second of these processes take place in trenches and ponds of brackish water, swarming with microscopic algae, to which the delicate green colour much prized by epicures is due. Education for transport consists of keeping out of water for a certain time individuals the shells of which gape open when removed from their natural element. By a repetition of this process oysters learn to keep their shells closed, and are then ready to travel. Some oysters need little training in this respect, having learned to close their shells immediately upon being brought to land.



ANODONTA. One stage in development;—a, byssus; b, adductor muscle; c, hooks, d, mouth; e, cilia; f, food canal, g, lateral pits.
Parker & Haswell

Life Story of Anodonta. Some bivalve molluscs, like *Anodonta*, live in fresh water ponds and streams, and in such instances either there are no free-swimming larvae, which would tend to be swept down to the sea and destruction, or, if they are formed, special arrangements prevent such a catastrophe. In fresh water mussels like *Anodonta* and *Unio*, the latter alternative is found in the life history. Development of the fertilized egg takes place in the lamellae of the outer gill of the mother, and a small bivalve larva, the *glochidium*, hatches out. The gills of a single ripe female are greatly distended with many thousands of such developing larvae.

The glochidia are shed into the surrounding water by way of the exhalant siphon. At this stage the shell is quite unlike that of the adult, for the valves are triangular and each free apex bears a sharp hook. A long adhesive thread, the byssus, trails out between the slightly gaping valves to seek an anchorage essential to further development. A strange set of events is associated with subsequent changes. The glochidia are liberated in small clouds at the precise moment when a fish passes close to the mother. Unless the larvae anchor themselves to the fish they must inevitably perish. Should the byssus touch the gills or skin of the fish, say, a stickleback, it holds fast and the hooked valves are employed promptly as a more permanent means of attachment. The irritation which is set up leads to the growth of a kind of gall, within which the later stages are passed through in comparative safety. After a parasitic life of varying extent the young mussel emerges from the cyst, falls from its temporary host into the mud of the pond floor, where it becomes adult and lives for the rest of its life.

LESSON 19

Spiny-Skinned Animals

ECHINODERMS, which get their name from Greek words meaning spiny-skin, differ from most animals we have considered thus far in the nature of their symmetry. Instead of having bodies with definite fore and hind ends and right and left sides, each the mirror image of the other (bilateral

symmetry), they resemble a star or the head of a regular flower. This type of symmetry, called radial, we have encountered already in the bodies of *Coelenterata*. But Nature's great experiment in radial symmetry has been made with the *Echinodermata*, which live in the sea at all depths and show interesting variation in form and structure, as well as great diversity in habits.

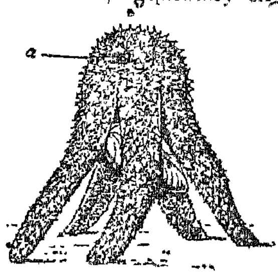
Most species live at moderate depths beyond low water mark, but many dwell in shallower water between tide marks. Some love to climb on rocky coasts, others to glide over or burrow into sandy beaches or estuaries. Their food is varied, as is also the manner in which it is obtained. Some swallow sand or mud, which they pass through their bodies in order to digest the living creatures contained therein; others browse upon or crop various kinds of seaweeds; a few find an easy living on beds of bivalve molluscs, and become pests on oyster beds and mussel banks. The animals included in the phylum fall into five clearly defined classes: (1) starfishes (*Asteroidea*); (2) brittle-stars (*Ophiuroidea*), (3) sea-urchins (*Echinoidea*); (4) sea-cucumbers (*Holothuroidea*), and (5) sea-lilies and feather stars (*Crinoidea*). The first two of these classes will now be considered.

Starfishes. These animals are so called because of their star shape, and are among the most familiar creatures of the seashore. The commonest kinds—like *Asterias rubens*, the "five-fingers," and *Astropecten irregularis*, the burrowing starfish—have five radiating arms growing out from a central disk. The mouth lies in the centre of the disk on its under side edged with strong spines. It leads into a capacious stomach, the first part of which can be protruded from the disk and literally wrapped around prey.

One of the most interesting features of the starfish is the way in which it moves about. It crawls along or climbs into and out of crevices by means of numerous sucker-like organs lodged in grooves, called ambulacral grooves, that run along the lower sides of the arms. These tube feet are generally distended with sea water, their cavities being continuous with definite channels and canals, which pass along the arms and around the disk. This system of canals constitutes the water vascular system, the most characteristic organ system of the echinoderm. It is essential to glance, first of all, at this important feature of echinoderm anatomy.

On the upper side of the central disk and towards the interval between two of the arms lies a small furrowed plate, the madreporite, which is perforated with numerous fine pores, seen only with the help of a hand lens. The perforations lead into exceedingly fine canals lined with cilia, which draw sea water through the madreporite and into a short vertical canal with calcified walls, called the stone canal. The stone canal conveys sea water into a circular canal running round the gullet and, therefore, immediately above the mouth. The " ring canal " gives off one radial canal opposite each arm, and this passes along the ambulacral groove above the tube feet. Short connecting vessels link up radial canals with tube feet.

The base of each tube foot is swollen into a vesicle or ampulla with muscular walls. This is really a reservoir for fluid used in connexion with the activities of the tube feet. By contraction of the ampulla water is forced into the tube foot, which is thus extended. In *Asterias* the tube feet end in disk-like suckers, by means of which the animal clings to the surfaces of rocks and weeds over which it scrambles. The water vascular system is thus an agency of locomotion, but this is not its sole function, nor yet its most important one. Projecting freely into oxygen-laden sea water and possessed of thin membranous walls, the tube feet are admirably adapted for effecting respiratory exchanges, and, in fact, they are very important breathing organs. The water vascular system was first evolved in the interests of respiration, which is still its chief function in sea-lilies and brittle-stars, and which only later in the evolution of the Echinodermata and in particular forms came to possess importance as the basis of locomotion.

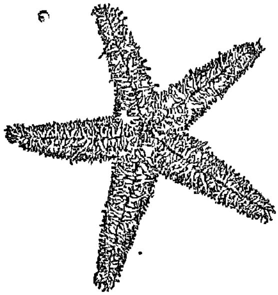


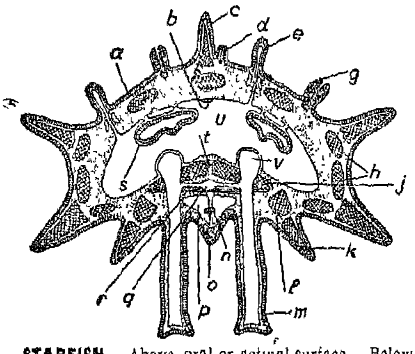
STARFISH in act of devouring a mussel in the manner described in the text; a, madreporite, through which water enters the stone canal
Borradaile, etc.

Starfishes prey upon apparently invulnerable bivalve molluscs to such an extent as to menace the shellfish industry. The star-fish arches its body over that of the mussel or oyster, and attaches its tube feet to the valves. The shell is gradually forced open by the long sustained pull of the tube feet, for the powerful adductor muscles of the bivalve, though much stronger than the tube feet, tire

much more quickly, and the succulent body of the mollusc is drawn into the protruded stomach of the starfish.

At each side of the ambulacral grooves of the starfish's body are two or three rows of calcareous spines movably articulated with plates in the body wall by means of ball and socket joints. Nearer the upper surface are three rows of stout immovable spines, while on the upper surface are numerous shorter immovable spines arranged in irregular rows along the arms. Some of the spines, especially those of the lower surface, have microscopic pincers borne on short flexible stalks. These are the pedicellariae, which serve to keep the surface of the animal clear of sand grains and minute sessile organisms, which are picked off the soft membrane that covers spines and plates as quickly as they fall on it. At the extremity of each ambulacral groove is a small bright red eye-spot, overhanging which is a minute tentacle, similar to a tube foot, but without a sucker. These are the organs of sight and smell, the latter being more strongly developed than the former in starfishes.





STARFISH. Above, oral or actinal surface. Below, diagram of transverse section of arm; a, epidermis; b, muscle which straightens the arm; c, spine; d, one of small pedicellariae with crossed jaw ossicles; e, gill; g, one of large pedicellariae whose jaw ossicles are not crossed; h, ossicles; j, ambulacral ossicle; k, adambulacral spine; l, adambulacral ossicle; m, tube foot; n, radial blood vessel; o, radial nerve; p, radial perihaemal vessel; q, radial water vessel; r, muscle which narrows ambulacral groove; s, pyloric caecum; t, muscle which opens ambulacral groove; u, perivisceral cavity.

From Parker & Haswell, "Text-book of Zoology," Macmillan; and Borradaile, Eastham, Potts & Saunders, "The Invertebrata," Cambridge University Press

The internal organs of the starfish are very complex, so that we can but glance at their nature. They project into a capacious cavity in the disk and arms, which is the coelom. The mouth leads into a stomach which occupies most of the space within

the disk, and is divided into two parts From the part furthest removed from the mouth eight long digestive sacs are given off, two of which pass into each arm The walls of these caeca secrete digestive fluid and are to be regarded as digestive glands The last part of the alimentary canal is a short intestine which opens to the exterior by a small anus almost but not quite in the centre of the upper surface of the disk

The nervous system shows the same radial symmetry as the digestive system Just below the epidermis of each ambulacral groove and between the rows of tube feet is a strip of nervous tissue or radial nerve This links up with a pentagonal strip of similar tissue, the nerve ring surrounding the mouth The blood vascular system shows a similar arrangement The gonads are built upon the same wheel like plan, the ovaries or testes resembling bunches of microscopic grapes in the cavity of the disk between adjacent arms Eggs and sperms are passed to the exterior through minute openings on the upper surface

A starfish hatches from the egg as a bilateral *bipinnaria* larva the body of which is drawn out into short soft arms covered with cilia The majority of echinoderms have free-swimming larvae which float in the sea, and the bipinnaria is characteristic of the starfish class A few starfishes, chiefly those of polar seas or of the ocean abysses, retain the young in special brood pouches until they come to possess the adult form The eggs of forms with pelagic larvae are small and almost devoid of food yolk, such eggs must drift for a space in the sea, from which materials requisite for development are obtained Other forms have larger yolky eggs containing most of the food materials necessary for development, in this case the young do not pass through a free-living larval stage in development, and for the early part of the life cycle live sheltered lives

Brittlestars. These animals are the most active of all echinoderms, and obtain their name from the habit they have acquired of breaking into pieces when touched or otherwise irritated The scientific name *Ophiuroidea* refers to their wriggling serpent-like movements The arms of the ordinary starfish are merely continuations of the central disk into which glandular prolongations of the stomach extend Brittlestars also possess radiating arms, but these are narrow and serpentine, sharply marked off from the disk and devoid of digestive pouches

In examining the arms of the brittlestar in greater detail we

encounter several differences from the starfish pattern. mo[illegible] search in vain externally for ambulacral grooves such as r[illegible] from the angles of the mouth in the starfish; in the brittlestar these grooves have been converted into closed canals lying buried in the body wall protected by calcareous plates, which have been derived from the plates bordering the grooves in *Asterias*. The closed canals are also found in sea-urchins and are known as epineural canals. At the sides of the plates project slender tube feet, which, being devoid of suckers, are of little use in climbing. The brittlestar uses its mobile arms for moving about, but independently of the action of the tube feet. One arm is extended in front, while the others row the animals along over sandy surfaces by series of spasmodic movements. The animal progresses by pushing and pulling upon the objects about it with its highly muscular, armour-plated and spiny arms. An alternative method of capturing prey has also been devised, for this the brittlestar achieves by coiling an arm around it and forcing it into the mouth. The thin, soft epidermis of the starfish, which is richly ciliated, is vestigial in the brittlestar, and in its place is a strong cuticle which defies laceration.

Many other features serve to render the *Ophiuroidea* distinct from the *Asteroidea*. The alimentary canal is a mere bag, which cannot be protruded through the mouth, and this opening is armed with sharp spines that serve as teeth. *Ophiothrix fragilis*, the common and most fragile of all brittlestars, feeds on microscopic sea plants and on decaying matter occurring in the mud on which it lives; it shovels sand and mud into its mouth with the first two tube feet on each arm. These tube feet are continually active, throwing food into the mouth and sweeping away undigested materials which must leave by way of the mouth.

The egg of the ophiuroid develops into a larva totally dissimilar to the parent and different from the bipinnaria of the starfish. It has long slender arms supported by fine calcareous rods and clothed with fine cilia, and bears a closer resemblance to the larva of the sea-urchin. Both types of larvae are called *plutei*, that of the ophiuroid being an *ophiopluteus*.

Our Course in Zoology is continued in Volume 5.

END OF VOLUME FOUR